ILLUMINATING ENGINEERING

MARCH, 1949

Third Internat'l Lighting Exposition
Fallacy of Louverall Ceilings
Lighting Idlewild Airport
Schoolroom Brightness Ratios
Lighting a Press Shop
Judging Reflectance

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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PENDANT TYPE DATA

Total unit efficiency	**59%**
Total lumens above 90 degree zone	**24%**
Side shielding	**27** degrees
End shielding	**13** degrees max.
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Total unit efficiency	**52.5%**
Shielding same as pendant unit	
Maximum brightness inside shielded zone	**2 c/sq.**" (904 FTL)

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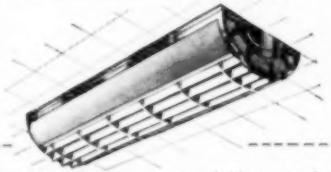

"Rex-Lite 40" Units are available in pendant or ceiling units. Either type can be installed independently or butted end-to-end to form continuous lines by using a specially designed coupling.

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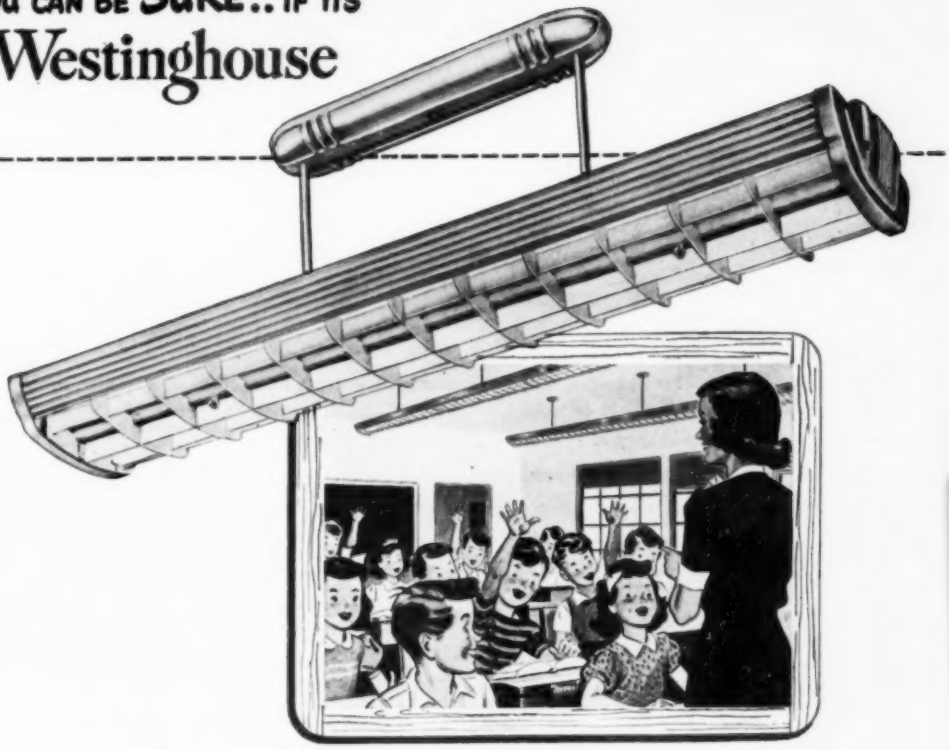

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

MARCH
1949

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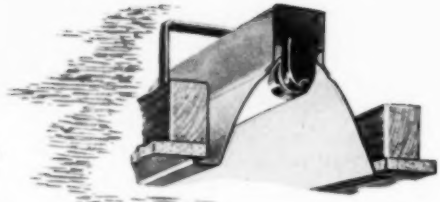

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Chicago, Ill.

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International Lighting Exposition Has Strong I.E.S. Appeal

By G. T. MORROW
CHAIRMAN, OPERATING COMMITTEE, I.L.E.

L. E. Tayler

G. T. Morrow

THE Third International Lighting Exposition to be held in Chicago during the week of March 29 focuses attention on the close correlation of lighting development and lighting application and the importance of having available practical tools for implementing basic lighting concepts. A study of the program as scheduled for the Hotel Stevens is bound to impress every illuminating engineer with the number of features which bear rather closely on his own work, regardless of how specialized this may be.

Interior lighting techniques and the fixtures or other devices which permit ideas to become usable play a very large part in the ultimate goals toward which all illuminating engineers are striving.

That this analysis is not new can be seen from the earlier conference records of the Illuminating Engineering Society. For many years a "fixture exposition" was part of each annual convention. This practice was dropped in the late thirties so that the Society could concentrate on the broader aspects of lighting research and development. The initiation of a separate lighting exposition a few years ago by the National Electrical Manufacturer's Association complements the Society's present policy

I.L.E. Program

Third International Lighting Exposition and Conference
March 29 through April 1, 1949 — Stevens Hotel, Chicago

Tuesday, March 29, Conference Session

Grand Ballroom, Stevens Hotel

Chairman: L. E. Tayler, President, Illuminating Engineering Society

10:00 A.M. — "Y B in Dark?" — G. T. Morrow, Chairman, Exposition Operating Committee.

10:03 A.M.—"New Light on Planned Lighting"—L. E. Tayler.

10:15 A.M.—"One Interest; One Goal" Welcoming Address — B. W. Clark, President, National Electrical Manufacturers Association; Vice President, Westinghouse Electric Corp.

11:00 A.M.—Presentation, Merit Awards —R. D. Bradley, Chairman, Merit Award Contest Committee.

11:50 A.M.—Procession to Exhibit Hall

12:00 Noon—Official Opening Third International Lighting Exposition—Exhibit Hall, Stevens Hotel.

Wednesday, March 30
Conference Session

Grand Ballroom, Stevens Hotel

Chairman: D. M. Salsbury, Vice President, National Electrical Wholesalers Association; President, Westinghouse Electric Supply Company.

10:00 A.M.—"The Wholesaler's Part in Lighting Sales"—D. M. Salsbury.

10:15 A.M.—"Where Do Business and Lighting Go From Here?" Eric Johnston, President, Motion Picture Association of America, Inc.

11:00 A.M.—"What the Lighting of the Future Will Mean to You"—A New Presentation and Demonstration by the Engineering Division, Lamp Dept. General Electric Co., Nela Park. Conducted by Alston Rodgers, Senior Lighting Engineer.

8:30 P.M.—Exhibitors' Night — Grand Ballroom, Stevens Hotel. Entertainment—presented by the Exhibitors.

Thursday, March 31, Conference Session

North Ballroom, Stevens Hotel

Chairman: Ralph P. Wagner, Chairman, Better Light, Better Sight Bureau; Commercial Manager, N. Y. Power and Light Corporation, Albany, N. Y.

10:00 A.M.—"The Power Company's Part in Lighting Sales"—Ralph P. Wagner.

10:15 A.M.—"How Atomic Power Will Affect the Future of Lighting"—Ward F. Davidson, Research Engineer, Consolidated Edison Company.

11:00 A.M.—"Glass Comes of Age"—Lecture and Demonstration, Harold G. Vogt, Research Physicist, Corning Glass Works.

Friday, April 1, Conference Session

North Ballroom, Stevens Hotel

Chairman: Robert W. McChesney, President, National Electrical Contractors Association; President, Harry Alexander, Inc.

10:00 A.M.—"The Contractor's Part in Lighting Sales"—Robert W. McChesney.

10:15 A.M.—"A Little Light on Color" —Julian Ellsworth Garnsey, Colorist.

11:00 A.M.—"Plastics, The New Look in Lighting" — Lecture and Demonstration — F. W. Tetzlaff, Plastics Dept., Rohm & Haas Co.

of one national meeting and numerous regional conferences each year.

I.E.S. President to Preside

The Exposition has been honored by the consent of the Illuminating Engineering Society's president, Mr. Lee E. Tayler, to preside at the opening session on Tuesday, March 29. In addition to presiding, Mr. Tayler will discuss briefly some of the problems of commercial and industrial lighting applications.

Typical of other subjects at the Wednesday morning, March 30, conference sessions are "Where Do Business and Lighting Go From Here"—an address by Eric Johnston, President, Motion Picture Association of America, Inc., and also President of Columbia Electric Manufacturing Co.—followed by "What the Lighting Future Will Mean to You,"—a new presentation and demonstration by the Engineering Division, Lamp Department, General Electric Co., Nela Park—conducted by Alston Rodgers, Senior Lighting Engineer .

At the Thursday morning, March 31, conference session, there will be an address, "How Atomic Power will Affect the Future of Lighting," by Ward F. Davidson, Research Engineer, Consolidated Edison Co. This will be followed by "Glass Comes of Age," lecture and demonstration by Harold G. Vogt, Research Physicist, Corning Glass Works.

On Friday morning, April 1, a talk, "A Little Light on Color," by Julian Ellsworth Garnsey, Colorist, will be followed by "Plastics, the New Look in Lighting," a lecture and demonstration by F. W. Tetzlaff, Plastics Department, Rohm and Haas Co.

"Gallery" of Winning Merit Award Entries

For the first time at any International Lighting Exposition, the winning lighting case studies in the Merit Award Competition will be displayed in Art Gallery Style around the walls of the Exposition Hall of the Stevens Hotel. All of the Merit Award entries in this year's competition are mounted on 24" x 36" boards so that visitors to the Exposition can study and examine photographs, blueprints, technical data and other details easily at their convenience. The Gold Seal and Merit Award winning case studies in this competition, which

THE CONFERENCE SESSIONS are always one of the most outstanding features of the Lighting Exposition, with men representative of every phase of lighting in attendance. This year, March 29 through April 1, even larger crowds are expected than those shown in this photograph of one of last year's sessions.

number over 100, represent the finest techniques and latest illuminating engineering practice employed in recent installations by architects, consulting engineers, utility lighting and power men, electrical contractors and wholesalers and users of industrial and commercial lighting. They were selected for top honors by the judges from a field of nearly 300 lighting case studies submitted.

Exhibitors to Show "Latest in Lighting"

Nearly 100 exhibitors are completing preparation of their booths which will display and demonstrate all the newest developments in industrial and commercial lighting equipment. Among these are the new luminous ceiling and troffer lighting; new ideas in fluorescent lamps and the sockets and fixtures for installing them, as well as new lighting devices and equipment.

The Exposition hours, Tuesday, March 29 through Friday, April 1, will be from 12 noon to 6 p.m., except on Thursday when the closing hour will be extended to 9 p.m.

Merit Award Presentations, Tuesday

At 11 a.m. in the Tuesday morning session the winners in the Merit Award Competition will be announced. R. D. Bradley, Chairman of the Merit Award Competition Committee, will present the Gold Seal and Merit Awards to the individuals responsible for the winning lighting case study entries.

(Continued on page 26A)

GOLD SEAL WINNERS of last year shown receiving their Merit Awards from Carl F. Zersen, chairman of the board of judges. Similar awards will be made this year. Front row, left to right: Mr. Zersen; E. J. White, New York; J. L. Phillips, Birmingham; William B. Campbell and J. F. Parsons, Buffalo; J. B. Martin, Pittsburgh. Back row: J. W. Leadbeater, South Bend; F. D. Wyatt, Chicago; C. B. Marsh, Amarillo; L. T. Kight, Pittsburgh; R. W. Brown, Cincinnati; F. N. Cooper, Lancaster, Pa.

List of Exhibitors—Booth Numbers

	Booth No.
Acme Electric Corp. Cuba, N. Y.	51
Advance Transformer Co., 1122 W. Catalpa Ave., Chicago 40, Ill.	43
All-Bright Electric Products Co., 3917 N. Kedzie Ave., Chicago 18, Ill.	89–90
Art Specialty Co., 3245 W. Lake St., Chicago 24, Ill.	75
Benjamin Electric Mfg. Co., Des Plaines, Ill.	105–106– 107–108
Bent Glass Works, Inc., 85-25 126th St., Richmond Hill 18, N. Y.	114
Champion Lamp Works, Div. of Consolidated Electric Lamp Co., Lynn, Mass.	136
Circlite Corp., 118 S. Clinton St., Chicago 6, Ill.	79
Compco Corp., 2251 W. St. Paul Ave., Chicago 47, Ill.	76
Corning Glass Works, Corning, N. Y.	149
Crouse-Hinds Co., Syracuse 1, N. Y.	125
Curtis Lighting, Inc., 6135 W. 65th St., Chicago 38, Ill.	67–68
Day-Brite Lighting, Inc., 5411 Bulwer Ave., St. Louis 7, Mo.	3–4–5
Eastern Fixture Co., Inc., 170 Vernon St., Boston 20, Mass	29–30
Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y.	145–146
Electrical Testing Laboratories, Inc., 2 East End Ave., New York 21, N. Y.	150
Electro Manufacturing Corp., 2000 W. Fulton St., Chicago 12, Ill.	49–50
Ender Manufacturing Corp., 260 West St., New York 13, N. Y.	120–121
Fleur-O-Lier Manufacturers 2116 Keith Bldg., Cleveland 15, Ohio.	7
The Fostoria Pressed Steel Corp., Fostoria, Ohio.	2
The Frink Corp. Long Island City 1, N. Y.	38–39
Garden City Plating & Mfg. Co., 1750 N. Ashland Ave. Chicago 22, Ill.	46
General Electric Co. 1 River Road, Schenectady 5, N. Y. Lamp Dept., Cleveland, Apparatus Dept., Bridgeport, Conn.	52–53– 54–55– 56–57– 58
General Lighting Co., Inc., 1527 Charlotte St., New York 3, N. Y.	45
General Transformer Corp., 4321 N. Knox Ave., Chicago 41, Ill.	28
Globe Lighting Products Co., Inc., 397 Seventh Ave., Brooklyn, N. Y.	74 & 100
Holdenline Co. 2301 Scranton Rd., Cleveland 13, Ohio.	47
Holophane Co., Inc., 342 Madison Ave., New York 17, N. Y.	11–12
Illuminating Engineering Society 51 Madison Ave., New York 10, N. Y.	144
Jefferson Electric Co. 25th & Madison, Bellwood, Ill.	25
The Jones Metal Products Co., West Lafayette, Ohio.	69
Krieger Publications, Inc., 114 E. 32nd St., New York 16, N. Y.	21
Kulka Electric Mfg. Co. Inc., 30 South St., Mount Vernon, N. Y.	123
Leader Electric Co., 3500 N. Kedzie Ave., Chicago, Ill.	124
Lighting Products, Inc., 2259 W. Park Ave., Highland Park, Ill.	70–71
Markstone Mfg. Co., 1901 N. Springfield Ave., Chicago 47, Ill.	119
McGraw-Hill Publishing Co., Inc., 330 W. 42nd St., New York 18, N. Y. "Electrical World" "Electrical Construction & Maintenance" "Electrical Wholesaling"	19–20
Merit Award 326 W. Madison St., Chicago, Ill.	126
The Miller Co. 99 Center St., Meriden, Conn.	116–117– 118
Mitchell Manufacturing Co., 2525 Clybourn Ave., Chicago 14, Ill.	109–110– 111–112
Moe-Bridges Corp. 1415 Illinois Ave., Sheboygan, Wis.	134
National Elec. Contractors Assn., Inc., 610 Ring Bldg., 1200 18th St., N. W. Washington 6, D. C.	143

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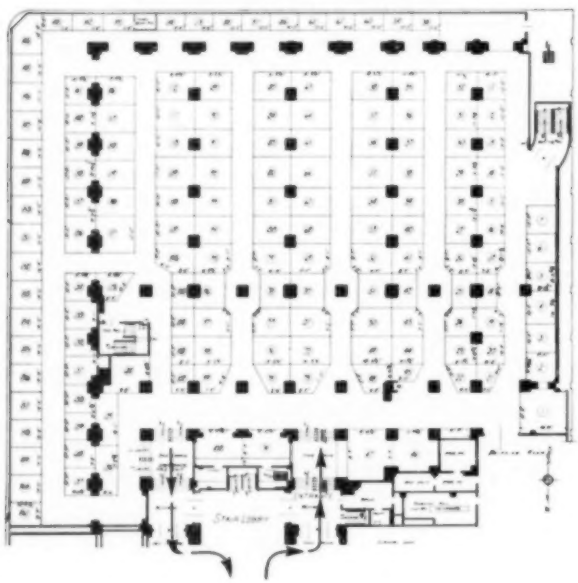
Floor Plan of Exhibits



The Lighting System for New York's New International Airport

By ADAM P. KOPF
W. A. PENNOW

"Idlewild Airport," New York City's new International Airport, being one of the largest air terminals yet built, is naturally of great interest to airport operators and engineers. In their I.E.S. Conference paper, the authors have outlined the lighting problems encountered.

WHEN New York's new International Airport was in the formative stages many problems were involved. The area of this project was so large that all of the airports around Metropolitan New York totaled only about half its acreage (Fig. 2). The traffic density forecast by the airline operators reached the staggering figure of 1500 per day, averaging more than one landing or take-off every minute. Traffic density during peak periods may reach more than twice that figure.

A tangential runway layout was selected as offering the most logical solution to the traffic problem, as the runways for incoming and outgoing airplanes are widely separated, providing at least two miles between air-borne positions at the respective ends of the runways (Fig. 1). This permits an airplane engaged in either a take-off or landing operation to maneuver through a considerable local area without interfering with other airplanes engaged in an opposite operation.

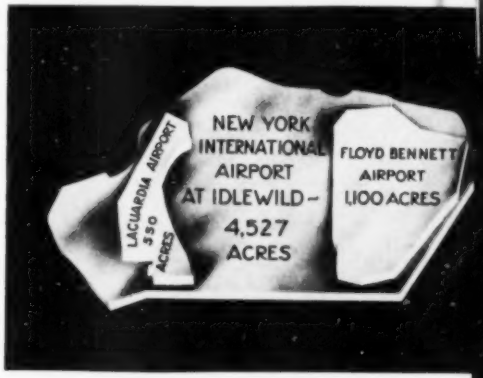
A study of the cycle of movements of an airplane, covering the approach, landing, taxying, unloading, servicing, loading, taxying and take-off was made for each runway direction and time values established for each part of the cycle on each runway.

A study was made of the wind rose for the area and all available meteorological data were analyzed to determine which runways and taxiways must receive preferential treatment, because of preponderance of traffic, or adverse weather conditions.

After completion of the studies and establishment of basic needs, without reference to available equipment, each problem of lighting was carefully analyzed to determine what equipment was best suited.

As this was a runway type airport, general field lighting was minimized. The surrounding area was surveyed and where obstructions could

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Boston, Mass., September 20-24, 1948. Mr. Kopf is with Sears and Kopf, Consulting Engineers, New York, N. Y. Mr. Pennow is with the Westinghouse Electric Corp., Cleveland, Ohio.



Figures 1 and 2. With Idlewild's immense acreage, a tangenital runway layout solves the heavy traffic problem.

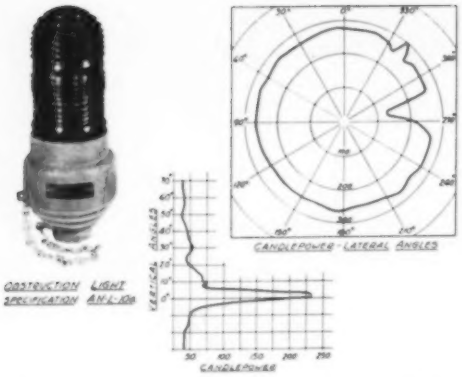


Figure 3. Where obstructions could not be removed, obstruction lights with optical glassware conforming to specifications AN-L-10 were specified.

not be removed, obstruction lights with optical glassware conforming to Specification AN-L-10 were specified for everything projecting above a 20 to 1 slope from the limits of the area, except in the approach or take-off zones at each end of each runway where lights were specified for everything above a 50 to 1 slope (Fig. 3). These zones are 500 feet wide at the end of the runway paving and 1000 feet wide at 3500 feet.

A 36-inch double-end beacon, having one clear and one green beam, 180 degrees apart, was located atop the control tower. This location was central, and insured minimum interference with the control officer's vision at night.

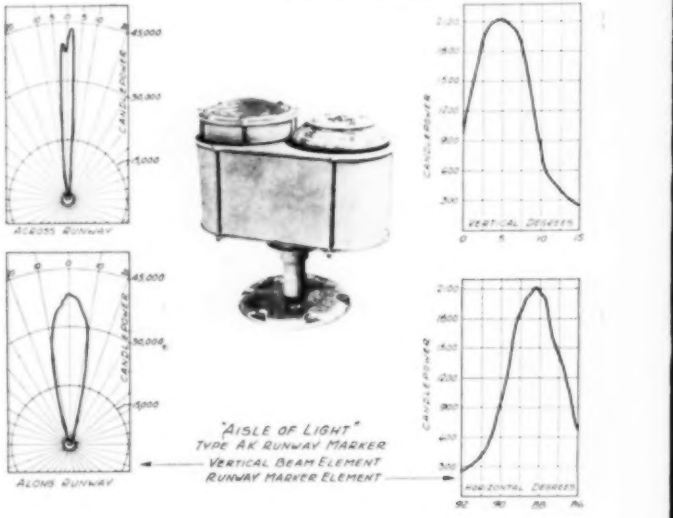
Runway type floodlighting was specified at each end of each runway. The divided system was chosen, with two 25-inch three-kilowatt floodlights with 10-degree spread lenses located at each side of each runway end. These provide an initial vertical intensity of 0.2 footcandle over the first 6000 feet of each runway for either take-off or landing.

The problem of runway lights was the subject of intensive study. It was felt that available apparatus did not offer a complete answer to the problem, and several recommendations were made. The senior author proposed that on one runway, a combination unit be used (Fig. 4). One part of this unit is similar to the standard semi-flush runway light, except modified by a small lens inserted in the relamping cover to provide some light directly upward, and a slight change in the regular lens to cause light across the runway to be depressed to keep it below the pilot's eyes and provide some surface illumination on the runway.

The second part of the unit embodies a new idea in runway lighting. This is the "aisle of light," wherein a wall of light is erected along each edge of the runway so that during hazy or smoky conditions the runway appears as a dark area between two walls of brightly lighted atmosphere. Also, it had been noted that haze or slowly moving smoke layers frequently covered the locality, these layers being 500 to 1000 feet above the area and seldom over one hundred feet thick. Under these conditions the whole layer is rather uniformly lighted to a low level by spill light from the loading areas and the terminal building group. The use of the "aisle of light" produces a much higher brightness in the haze or smoke layer above the runway, when observed from above the layer, appearing as a single line or a double line depending on the height and depth of the layer. This is of material aid to the pilot approaching the airport above the layer, giving the exact location of the runway below the layer of obscuring media.

Each of the "aisle of light" units consists of a 300-watt sealed beam lamp and a rectilinear

Figure 4. To solve the problem of runway lights it was proposed for one runway to use a combination unit, consisting of the standard semi-flush runway light and the "aisle-of-light" idea.



spread lens to fan out the light parallel to the runway. The units are spaced on 200-foot centers with provision for 100-foot spacing in the future. The fanning effect forms an interlocked solid wall of light a short distance above the runway.

The combination unit provides standard runway lighting during clear weather, with standard brightness control, and adds the "aisle of light" when weather conditions are less than clear.

Another runway is equipped with a new extremely high intensity runway light, having a maximum candlepower nearly 200 times that required for standard semi-flush runway lights and five times that of the high intensity runway lights used by the armed forces for low visibility use (Fig. 5). This high intensity unit as developed for Idlewild is a composite unit employing three lamps. One part of the unit has essentially the same photometric performance as a standard elevated runway light plus upward light for high angle visibility. The high intensity parts are unidirectional instead of the customary bidirectional arrangement. Separate lamps are provided for each direction. This arrangement prevents setting up of fog curtains between units and increases the effectiveness of the unit. The arrangement permits use of the units as standard runway lights plus, with full brightness control during clear weather, and as super high intensity runway lights with brightness control during various conditions of restricted visibility.

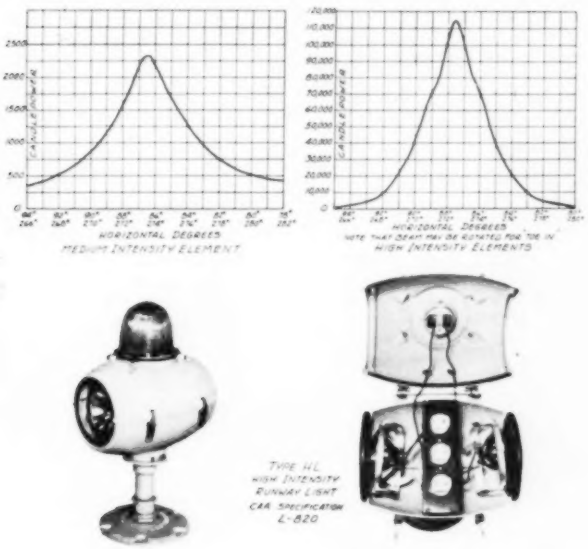
A third runway is equipped with Air Force type D-1 high intensity runway lights. As these three runways will be in operation several months before the completion of additional runways, close records of the performance and pilot's comments on each of the three systems will be kept. Lighting of the remaining runways will be based on the system proving best under actual service conditions.

The taxiway lighting is laid out on a full block-control basis to permit complete control of all airplanes on the taxiways at all times (Fig 6.) Separate pre-set arrangements are used for each runway for landing or take-off operations to avoid any possibility of error on the part of the taxi control officer. If taxiway control is set to direct an airplane outgoing on a runway, the parallel runway is automatically set to direct an incoming plane only. All contra movements on the controlled runways are blocked and taxi traffic to or from other runways is automatically blocked. All taxiway lighting is in facsimile on the taxi control board so the taxi control officer can see at all times the exact setup on the airport and the position of each airplane in the ground traffic pattern.

With the high traffic density forecast for Idlewild, it was obvious that the usual practice of maintaining radio contact with all airplanes in the airport traffic pattern would be impossible. The study of traffic and the time values established were used in evolving the traffic control methods, which consist largely of lighting. Radio contact is made with approaching airplanes and landing sequence assigned to each airplane before it enters the airport traffic pattern. Radio contact is also made with airplanes ready to leave the loading area and taxying route and take-off sequence assigned. Except for emergencies, no further radio contact is made with airplanes within the airport traffic pattern, and all control of landings and take-offs is by lighting means.

Airplanes taking off follow their assigned taxi route to the take-off position, with the route lighted by taxi guidance lights and taxi progress control lights. The airplane is free to take off when ready as soon as it is cleared into the take-off runway.

Figure 5. Another runway was equipped with a high intensity runway light, employing three lamps, with the high intensity parts unidirectional instead of the usual bidirectional.



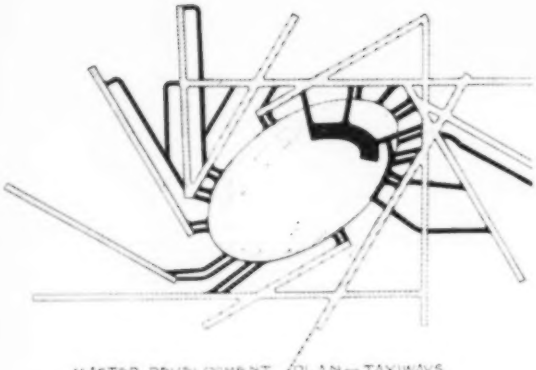
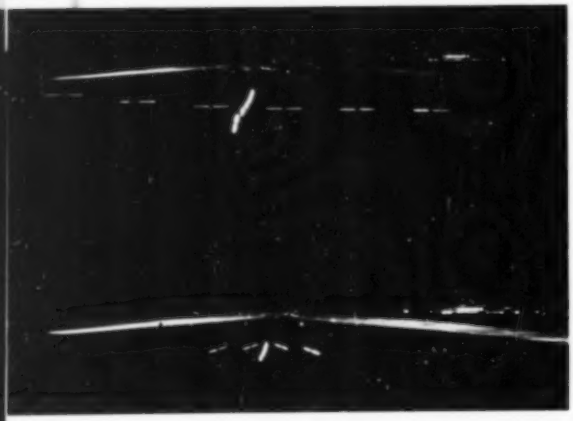


Figure 6. The taxiway lighting is laid out on a full block-control basis to permit complete control of airplanes on taxiways at all times.

Airplanes entering the airport traffic pattern after assignment of landing sequence "follow-the leader" into the approach zone. At the inner end of the approach zone is the runway designator, a large traffic control unit made up of luminous tube elements, which appears as a green arrow on the center line of the runway, pointing toward the runway, showing that the runway is clear for landing (Fig. 7). If, for any reason, an emergency develops where the runway would be unsafe for the landing, the traffic control officer changes the green arrow to a flashing red cross, closing the runway. Airplanes on the approach

Figure 7. At the inner end of the approach zone is the runway designator, consisting of luminous tube elements, which appears as a green arrow, changing to flashing red cross (above) when unsafe for landings.



then pull up and continue in the traffic pattern, succeeding airplanes being notified by radio to maintain positions in the pattern until the emergency has cleared. Resumption of traffic flow then requires radio contact only with the leading airplane.

As an airplane lands, it continues along the runway until the proper taxi exit, marked by lights, is reached. It then turns off the runway and follows taxi guidance lights and taxi progress control lights to its position in the unloading area.

The use of widely spaced parallel runways required special treatment of wind indication. A standard tetrahedron is used as a master landing direction indicator. Externally lighted wind cones, three feet in diameter and 12 feet long, are mounted near the inner end of the take-off runways to give precise wind direction to departing airplanes. Smoke generator type wind indicators are mounted near the approach end of the landing runways. The smoke plume gives indication of wind direction to incoming airplanes, and warns the pilot of any gustiness or swinging direction of the wind near the point on the runway where contact is made.

The subject of approach lighting was intensively studied and discussed at great length with representatives of the Airline Pilot's Association, with Air Transport Command Pilots, and with the Airlines' operational groups. Many tentative layouts were made before plans were agreed on.

The approach light system is installed at the southwest end of runway "C," extending 3000 feet from the runway threshold. As the Jamaica Bay shoreline is only 900 feet from the threshold, a pier 2200 feet long was built out into the Bay. The middle radio marker of the CAA Instrument Landing System (ILS) is mounted on the extreme outward end of the pier (Fig 8). The approach lights are installed along the right edge of the pier, in line with the left row of runway lights, starting 100 feet from the middle marker. Spacing is 25 feet apart in line for the outer 1000 feet, 50 feet apart for the center 1000 feet and 100 feet apart for the 1000 feet nearest the threshold.

The approach lights use two new type lamps, a Krypton Flash Lamp, which is several times brighter than any other known light source; and a high pressure pure neon tube having electrodes capable of operation on alternating current for fixed lights or on direct current as condenser discharge lights of high brightness. Lights using krypton lamps are alternately spaced with lights using neon lamps, 35 of each comprising the approach line.

In operation, several steps of brightness are available so the step to suit any specific weather condition, day or night, can be selected by the airport control officer. The units with the high pressure neon tubes, called "Blaze" units, may be operated as fixed lights of 100, 1000 or 10,000 candlepower, as selected. They may also be operated as condenser discharge lights of 100 thousand or 10 million candlepower. The units with krypton lamps, called "Flash" units are operable only as flashing lights of 1 million or 3.3 billion candlepower as selected.

When operated as flashing lights, the precise moment at which each unit flashes is controlled by a circuit from a master synchronizer. The outermost unit is flashed first, then each successive light toward the runway threshold flashes in sequence, generating a wave of light that has the appearance of a lightning stroke traveling toward the runway at a speed of over 4000 miles per hour. The duration of the full flash is about one-half second, with about a one second eclipse between flashes. The complete cycle repeats about 40 times per minute.

The duration of individual flashes, measured at one-third of maximum candlepower, is about 17 microseconds for the Flash unit, and 90 microseconds for the Blaze unit.

This duration ratio is shown in a striking manner in Fig. 8. This photo was taken with a shutter speed of 1/250 second. Note that five of the Blaze units are lighted, while only one of the Flash units is lighted.

The predicted range, or forward visibility, in any specific weather was one thousand feet minimum, measured along the pilots' line of sight. After one and a half years of actual service testing on a short experimental system, and after flight tests and ground observations of this installation, it is obvious that this prediction was most conservative. Daytime observations during the heaviest fogs encountered have never shown less than twice the predicted range. Night-time observations have shown the expected increase in range over daytime. The data from the observations is insufficient to permit accurate statements of visibility ranges, mainly due to incomplete data describing the fog densities prevailing at the time the observations were made.

Control of the entire lighting system is centered in the control tower. The airport control officer directs all traffic flow, with the radio officer, traffic control officer and taxi control officer executing his instructions. The radio officer contacts all incoming airplanes before they enter the airport traffic pattern and all outgoing airplanes before they leave the loading area. The traffic control officer directs all air-borne traffic within the airport traffic pattern, and operates the beacon, obstruction lights, approach lights, runway designators, runway floodlights, wind indicators, and runway marker lights.

The taxi control officer directs all earthbound traffic on the airport and operates the taxi guidance lights, taxi progress control lights and the taxiway block signal system.

After the airplane enters the approach zone in the airport traffic pattern, all movements, approach, landing, taxying to the unloading area, taxying from the loading area to take-off position and clearance for take-off are controlled by lights. In bad weather the same procedure is followed with the exception that clearance to enter the approach zone is given to each airplane separately as the airport traffic pattern is then under altitude control.

All runway lighting units off continuous paved areas are elevated, with the highest projection above grade not exceeding 30 inches. Special mounting plates and supporting shafts were developed, each shaft having a shear notch at cover level. Waterproof rubber disconnecting plugs are mounted in the plate and shaft so that any collision with a light will break the shaft flush with the top of the cover and disconnect the light electrically, preventing damage to the power supply system.

All lights equipped with multiple service lamps

Figure 8. The middle radio marker of the CAA instrument landing system is mounted on the outward end of the pier, with the approach lights installed along the right edge of the pier in line with the left row of runway lights.

and operated from series circuits have insulating transformers with primary and secondary disconnecting terminals. All electrical components on the field are fitted with plug-in connections to facilitate servicing and replacement.

Monocycle Square constant current regulators are used in all circuits requiring brightness control. Moving coil type regulators are used on the "aisle of light" units, as brightness control is not involved and the heavy wattage load is best supplied by moving coil regulators.

Standard runway selector cabinets are used to shift the regulator supply for the runway lights to the proper runway. The runway floodlights and smoke generators are fed from a 2400-volt loop, with primary switching at each location. The externally lighted wind cones are fed from the runway marker circuit for each runway through an insulating transformer.

Taxiway lighting is supplied by a series circuit, using short-circuiting relays to operate the block system of control. This has the great advantage of avoiding voltage drop effect on any light in the system. This is very important, as the blue color of the taxi lights requires that each lamp operate at normal voltage. When an incandescent lamp operates at reduced voltage, its major output is in the red-orange part of the spectrum and the blue filters block this, making the light appear very dim and useless in daytime.

Many new and revolutionary ideas and many new items of equipment and control are being used at Idlewild. Most of the traffic is transocean and transcontinental, using large, heavily loaded airplanes, and engineers believe that faster, safer handling of this traffic will result from these advances in the art of airport lighting.

DISCUSSION

J. B. Bartow*: New York City's International Airport is of great importance to airport operators and engineers. This is particularly true in reference to its lighting equipment, as the greatest economical and safety problem confronting air transportation today is that of maintaining scheduled landings and departures during restricted visibility conditions. In evaluating or designing an airport landing system, it should be remembered that automatic pilots, radio, instruments, and other electronic aids only help to solve the problem of landing during restricted visibility conditions and for commercial operations, the pilot must depend on visual reference to the ground to make final approach and landing. This lighting installation becomes of added importance as it has a lot of shining examples of what not to do.

Twenty years ago on all-way fields and before runway outline lighting, flood lighting in conjunction with boundary lights was the standard equipment for night landing, as the flying was limited to contact conditions. It is obvious that this became obsolete, because it was useless when the atmosphere contained a quantity of snow, smoke, etc. Flood lighting, of course, is also useless during any daylight conditions. It is true that on some fields where they have flood lights installed and do not have adequate runway outline lights, that they operate them, not as a flood light, but to mark the far end of the runway in order to try to give the pilot something to see.

The first runway unit described, or Type AK Runway Light, is an outstanding example of what not to do, as this is a combination of obsolete equipment and ideas. This unit utilizes the semi-flush runway light, which was standard prior to World War II, and is not satisfactory for bad weather operation. The second part of the unit, which is called the "aisle of light," is not new, as it is the same principle as the original flush runway marker lights. This principle was found impractical for even contact type of weather and was discontinued. While it may have a pretty effect to an artist during certain night atmosphere conditions, it is of little value to a pilot and it is quite obvious it will even lose this during any daylight operations.

In describing the second light, the HL type of light or CAA specification L-820, they state that this unit has five times the candlepower as that of the high intensity runway light used by the Armed Forces. They do not state which unit they are referring to. If they mean the Type D-1 unit, which was so successfully used during the war, this is certainly not true, and if they are referring to the Army Type M-2 unit, their statement is merely a play on words, as Type M-2 unit required 20,000 candlepower for 6° spread and this unit certainly does not have five times that by their own candlepower curve. It is stated that the unidirection feature prevents setting up of a fog curtain between units. The halo about the light which forms the fog curtain is fifty times greater from the front beam of a bidirectional unit than that caused by the back beam of the bidirectional unit. This has been proven out in actual field tests, for example — recent tests at Arcata, California. I would like to refer those interested to a paper by L. M. K. Boelter and F. A. Ryder — titled — "Notes on the Behavior of a Beam of Light in Fog" appearing in ILLUMINATING ENGINEERING, Vol. 35, No. 3, March, 1940. This fog curtain can be successfully eliminated by controlled distribution of the front beam in relation to atmospheric transmission and the path of the observer.

The mere statement "A third runway is equipped with Air Force Type D-1 High Intensity Lights" while it is also not true, it is quite obvious that this paper is a publicity release for only certain equipment. These units were not D-1's, but were an improved D-1 unit, having the feature of being able to remotely control the beam pattern as well as the brightness of the lamp in relation to the atmospheric conditions prevailing. This feature eliminates the fog curtain about the light, increasing the effectiveness of the unit and permits the use of very high intensity without glare. The units properly installed meet CAA specification L-818, but since the engineers did not install enough capacity to operate them as such, they have to be operated with a 200-watt lamp in place of the specified 500-watt lamp. Incidentally, this equipment was installed on Runway C, which is the main runway for landings during restricted visibility conditions. Therefore, even this runway is not as well equipped as other airports throughout the world, as many of the most important terminals are installing runway lights according to specification L-818. The L-818 runway lights have since been installed at New York's La Guardia Field.

The approach lighting system, while spectacular and at-

*Bartow Beacons, Inc., Bluebell, Pa.

tractive under some conditions, can only be considered as it applies to restricted visibility conditions when the visibility is such that the runway lights cannot be seen far enough out on the approach to properly coordinate with other approach aids. Under these conditions, it is highly important that a level ground plane be established to give the pilot the information he uses in any visual approach to landing. A single row of lights does not do this and under such conditions can become a hazard rather than an aid, since it can cause a pilot to have an optical illusion. This has been the cause of many fatal accidents such as the one at Lisbon, Portugal and at Port of Spain, Trinidad. The flashing of the light will tend to make this hazard even greater. In an article by Mr. A. L. Lewis, Senior Airport Engineer, Landing Aids Section, Naval Bureau of Aeronautics, on "Progress in Landing Aids at Arcata" and published in the May 1948 issue of *Aero Digest*, it states "The single row was not favored by test pilots as an approach light system."

The fallacy of using red lights to distinguish safe area for a pilot to let down over and at the same time to designate dangerous areas to be avoided should need no further comment. However, since a single row is dangerous, perhaps it should be marked as such.

The figures quoted pertaining to the approach lights as to candlepower, duration, speeds, etc., are interesting as to how they were arrived at since they do not tally with accepted laws or simple mathematics. For example, the speed of the wave of flashes towards the runway is given at 4,000 miles per hour, which is 58,666 feet per second and since the approach is 3,000 feet long, it would only take .051 seconds to travel this distance, yet they state that the flash duration is about one-half second.

It is stated that the light has up to 3.3 billion candlepower and that it is visible for 1,000 feet in any specific weather. In a previous presentation before the Aviation Committee of I.E.S. in June 1948 at New York and also in advertisements pertaining to this unit, it states —"This Approach Lighting System is visible through 1,000 feet of the thickest weather when objects 50 feet away cannot be seen." Now, according to Allard's Law, for a steady point source of light that can be seen through 1,000 feet of such a condition at night, the light would have better than 3.3 billion times 3.3 candlepower. This is for night visibility with a 0.2 kmc reception, and so during daylight such a light would have 1,000 times more candlepower and this would be providing it was a point source or approximately two inches in diameter at 1,000 feet. If the source were larger, due to a reflector, then it would mean that the candlepower value of the light was still greater, if visible at this distance. In other words, for a steady light to be visible at 1,000 feet during such a daylight condition, it would have more than 9.9×10^{30} candlepower. For a flashing source of 17 microseconds, which was the time given for the flash, such a light would have to have 14,000 times more light than for a steady source, so we now have 12.8×10^{34} candlepower. (For reference on flashing sources, see Blondel and Ray, I.E.S., Vol. 7, page 625, 1912, Lash and Prideaux, ILLUMINATING ENGINEERING, Vol. 38, No. 9, November, 1937; also a paper presented by Langmuir and Westendorp, ASME, November 30, 1931.)

W. H. EDMAN*: The authors have not only presented a paper on a large project, but a large subject and a most important one.

Perhaps there is no aspect of the lighting industry today in which there is more confusion and greater controversial issues. There are many points that have been brought up in this paper, in which great detailed discussion could be presented. However, to minimize this discussion, I should like to pick out some of the more important and perhaps more controversial points.

I am going to try to approach this strictly from an engineering point of view and confine it basically to the bad weather landing problem. The daylight bad weather problem is, of course, the worst. Good weather is no longer a problem, and I don't think we should spend any time on it.

For bad weather landings the approach is the opposite of what it was a few years ago. We then had the floodlights, and it was a matter of illuminating the runways. For bad weather this is the wrong thing to do. Today we think in terms of landing airplanes by delineation and, in effect, the lighting units become signal sources rather than illumination sources.

It is further recognized that in bad weather we must provide, by visual aids, the necessary elements which will set up a synthetic perspective for the pilot which, in turn, gives him the basis for being able to judge at every instant, the five basic elements, namely —

1. Altitude
2. Attitude
3. Distance
4. Direction
5. Speed

If the pilot cannot judge at each and every instant all of these five elements, he is liable to get into trouble.

I should like to ask the authors of this paper why obsolete floodlights were installed at Idlewild Airport.

The authors speak quite a bit about the so-called "aisle of light" unit which is a new idea and which has been given considerable publicity.

This two-element unit may be new as a unit for Idlewild, but certainly the principles or the ideas have been tried before. Let us analyze this strictly from a technical point of view. The one element with the flush contact light is, of course, for clear weather operations. The secondary element, shooting a powerful beam of light in a vertical direction, has been tried before and found wanting. Applying simple physics of light, it is quite easy to understand why it cannot be expected to do the job of providing the visual information needed to judge the five basic elements which the pilot so badly needs. In fact, the original flush contact lights had a beam of light that was shot straight upward, and much experimenting has been done on this previously.

I should like to correct the reference, that "A third runway is equipped with Air Force Type D-1 high intensity runway lights." The unit on this runway is of an improved type over the so-called Bartow Army D-1 unit, and has the added feature of moving the beams to make the unit more effective for all bad weather operations.

The author states that one of the runways is provided with an extremely high intensity runway, giving five times the candlepower of the runway lights used by the Army Air Forces for low visibility use. If the author is referring to the Army Type D-1, which is the only unit that they have used and are still using, with the exception of some experimental installations, then I should like to point out that this does not appear to be correct. The minimum specification for the Bartow D-1 was 32,000

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candlepower which, multiplied by five, would be approximately 160,000 candlepower.

I should like to make a few comments on the approach lighting system of the flasher type, which has aroused considerable interest and controversy in the aviation lighting industry. The last paragraph on page 9 of the preprint refers to the "predicted range or forward visibility for any specific weather condition" as being "1,000 feet minimum." I assume the authors mean that the approach lights are designed to be visible to the average pilot at a minimum distance of 1,000 feet in the worst weather conditions. I have also noted previous publications and claims for this system to the effect that it would be visible to the pilot through 1,000 feet of the thickest weather, when objects 50 feet away cannot be seen. The author does not state what the lowest visibility was at any of the tests that have been conducted during the past year and a half, on a trial installation which I believe was at Cleveland, Ohio.

I should like very much to have the authors give more specific data to support their claims that the performance is more than meeting their predictions.

I would like to ask the authors how they regard Allard's Law when working in fog. Also, how do they regard the Blondel and Rey formula for flashing lights? Without going into specific mathematics, it is very obvious that in applying Allard's Law, even for a steady burning light the 3,300,000,000 candlepower cannot be detected by the human eye under those conditions. Then to diminish the effectiveness further, the Blondel and Rey formula has to be applied so as to compensate for the short duration flash.

This all adds up to astronomical figures in candlepower such as we have never heard of before. So until such time as more substantiating experience and factual data have been obtained, I recommend that in our aviation lighting work, we do not cast aside accepted and well established laws of physics.

A. P. Kopf and W. A. Pennow:* As Mr. Bartow and Mr. Edman raise substantially the same questions in their discussions, one set of answers should suffice.

Floodlights—There are many operating conditions where the use of runway floodlights is most effective, such as assuring the pilot that the runway is clear of obstructions, most important in this case where field construction will continue for several years; providing emergency runway illumination in case of failure of runway marker light circuits; and during the period when heavy snowfall is being removed. Exploring the latter case, New York is subject to heavy snowfalls, which, when plowed off the runway, will completely cover the runway lights. Until the runway lights are dug out, runway floodlights provide the only type of illumination that will permit night operations in non instrument weather. Experience at other major airports in snow areas shows that during an average of five nights each winter, operations would not be possible without runway floodlights. With a forecast traffic density of over sixty airplane movements per hour, it is reasonable to assume that some three thousand operations per year will proceed as scheduled because good runway floodlighting has been installed.

"Aisle of Light"—As the discussion disregards the text, and concerns itself only with the probable performance during extremely low visibilities, or instrument weather; and as the "Aisle of Light" is not intended for, or expected to be used during such conditions, no comment is necessary.

New extremely high candlepower runway light—The text clearly states "having a *maximum* candlepower—five times that (required) of the high intensity runway lights used by the Armed forces for low visibility use," Air Force Specification #32957, which supersedes the Bartow D-1, requires a maximum candlepower of 20,000. Mr. Bartow discusses the unidirectional feature by pointing out that the halo, or illuminated fog curtain from the front beam of a bidirectional light is fifty times greater than that from the back beam. He neglects to mention that the halo from the back beam may be as much as 800 times greater than that from the front beam from the unit next in line, 200 feet further down the runway, and that this halo from the back beam cannot be successfuly controlled—particularly as the most intense part of the halo crosses between the pilot and the unit next in line ($200^2 \div 50$). We want the pilot to see as many lights in line as possible.

A third runway—using Mr. Bartow's words—the Bartow controllable beam, L-818, unit is now properly publicized.

Approach Lighting System—This is, of course, the most controversial subject among pilots and aviation lighting engineers. Many systems have been advocated and all but three have been eliminated by exhaustive flight tests. The remaining two, one proposed by Mr. E. S. Calvert of England, and the other as installed at Idlewild, have yet to receive full test procedures. The authors have no intention of using this paper, its discussions or rebuttals, in an attempt to explore all the ramifications of approach lighting.

However, direct questions have been asked concerning the effect Allard's Law and Blondel and Rey's theories have when applied to super high intensity lights of this type, and several calculations are presented.

First—Allard's Law—When applied to fixed lights, the factor "E," Threshold Illumination (Brightness Level) increases to a huge value when the candlepowers of the sources are raised to levels sufficient to provide threshold visibility. As Mr. Bartow's calculations show, the point is quickly reached where required increases in candlepower are astronomical. As the candlepowers of the sources are increased, the brightness level in the obscuring media is increased also, thus requiring further increase in source candlepower, etc.

Blondel and Rey—Here we have nearly a parallel case, where the factor "A = 0.21 seconds" is used to maintain threshold visibility as threshold illumination is increased.

In both cases the fallacy is in the misuse of Laws having factors which have very significant values when applied to fixed lights, or to flashing lights of sufficient duration to affect brightness level (dark) adaptation of the eye. These Laws have entirely different meanings when such factors have insignificant values.

For example in Blondel and Rey's theory, using a flash duration of 17 microseconds, followed by an eclipse of sufficient duration to allow complete return of the eye to previous steady state, the contrast factor (threshold) "Ef" becomes significantly larger than factor "Eo," while "A = 0.21 seconds" practically disappears.

Similarly, in Allard's Law, factor "E" remains substantially constant at the value applying when the interfering media is not illuminated by the approach lights.

Mr. Bartow comments on the duration, speeds, etc., of the flash, but he has decimal point trouble. The text is correct.

*Authors.

A Simple Method for Judging Reflectance

By DOROTHY NICKERSON

Illuminating engineers are finding more and more often in their professional work that the question of color must be considered. One reason for this is that there is a very considerable difference in the energy distribution of the newer sources as compared to the older tungsten sources, with a consequent difference in the way these newer sources affect the color of samples seen under them. Another reason is the current color consciousness of the public, and the growing requirement for more color as well as more light in the interior environment.

THERE IS MUCH about color that is not yet reducible to figures and formulas for use in solving engineering problems. On the other hand, there is already available a very considerable body of engineering data that could be applied if one knew where to find it, or how to apply it. Such data are widely scattered, being published chiefly in the periodical literature and very often familiar chiefly to the specialist in colorimetry. One such class of data could be applied with considerable ease to problems of illuminating engineering if a simple method for judging reflectance of colors were available.

Recommended practices refer constantly to reflectance or reflection factor. It is one of the several things necessary to know in lighting application when brightness and illumination levels are to be considered. The a-b-c of the matter is, of course, that illumination is measured in footcandles, and brightness is measured in footlamberts. A surface such as magnesium oxide has a reflectance of nearly 100 per cent. If it is illuminated to one footcandle, its brightness is one footlambert. A black velvet surface has a reflectance of approximately one per cent, and would require 100 footcandles of illumination to provide one footlambert of brightness. Thus, in order to specify the level of brightness, one must have a fair idea of the reflectance of the materials he works with, or the paints he wants to specify.

Brightness* is one of three terms used to define psychophysical color. It is the "Y" of an I.C.I. "(X, Y, Z)" color specification, or the "brightness" of a "dominant wavelength—brightness—purity" specification. Thus it is only one of three terms necessary to complete a color specification. It is, however, the most easily understood and most easily specified psychophysical color factor with which an illuminating engineer must deal.

Wherever I.C.I. data are available for color samples, the Y figure is equivalent to reflectance under whatever luminator is used as the reference point. Such data already are available for several collections of color samples: Munsell, Ostwald, and the standard card of the Textile Color Card Association of the United States, Inc.

Per cent reflectance of a surface color is something that can be measured on a number of instruments. Such instruments are not usually at the immediate disposal of most illuminating engineers, and per cent reflectance is not something easy to judge directly.

An indirect method that may be learned, and can be applied after a little practice, is one that involves use of the more nearly psychological color attributes: hue, lightness, and saturation, as they are specified in the Munsell scales of hue, value, and chroma. The Munsell value scale was adopted after much experimentation to find a set of samples that would look equally stepped from black to white, against a gray background, under daylight illumination.

A colored surface that looks halfway between black and white in lightness does not reflect half of the light that falls on it, as might be supposed—in fact, *is* supposed—by many. Instead, such a color reflects only about 20 per cent of the light falling on it.

Scales to represent equal intervals of lightness are not difficult to understand. Within a wide tolerance limit one can look at any color and judge whether it is near-white, or whether it is light, medium, dark, or near-black. If to such a word scale one applies numbers from 9, for near-white, through 7, 5, 3, to 1, for near-black, with even numbers for intermediate steps, even the novice has a scale that he can apply to obtain a reasonable answer. If an illuminating engineer would keep in mind a conversion from this easily and directly applied value scale into terms of per cent reflectance, he would be able to make reasonable judgments of reflectance of colors under

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*"Brightness" by I.E.S. definition; "luminance" by O.S.A. and I.C.I. definition.

whatever quality of illuminance he happens to be working.

Only non-selective neutral samples hold the same per cent reflectance under all kinds of illuminations. On the other hand, a vermilion sample, that is, a maximum red, when viewed under daylight will look medium-dark in value; under tungsten it will look lighter; under blue sky it will look darker. Fortunately, one is able to judge directly the lightness of any sample for the illumination under which it is viewed. For identical samples this lightness may be converted to provide a figure for per cent reflectance for the illumination under which the sample was viewed.

Thus, a conversion table for value (which the engineer can judge), to reflectance (which few can judge directly), is a rather necessary tool for any illuminating engineer. It should be easy to remember that reflectances of the original Munsell value scale were the square of the value numbers, but that the present and more accurately derived scales are even less than this, 5/ value reflecting just under 20 per cent. The scale is as follows:

9/ value is approximately equal to 79 per cent reflectance.
7/ value is approximately equal to 43 per cent reflectance.
5/ value is approximately equal to 20 per cent reflectance.
3/ value is approximately equal to 6.5 per cent reflectance.
1/ value is approximately equal to 1.2 per cent reflectance.

Value scales showing color samples with their reflectance for a number of illuminants have been developed by cooperation of the Illuminating Engineering Society and the Inter-Society Color Council delegates.[1] They are very handy to use, and will enable one to judge reflectances to fairly narrow tolerances. However, whether one owns a copy of the chart or not, the principle upon which they are built, and a simple value-reflectance con-

[1]This cooperative IES-ISCC venture is described by Norman Macbeth in the February, 1949, issue of ILLUMINATING ENGINEERING.

Table 1. Per cent diffuse luminous reflectance (%R) for actual samples under several illuminants.

These data are equivalent to the Y tristimulus values calculated from spectrophotometric data. For the daylight reflectance of each sample, use reflectance under Illuminant *C*.

Theoretical		N	R		YR		Y		GY		G		BG		B		PB		P		RP	
Value	Illuminant		L	M	L	M	L	M	L	M	L	M	L	M	L	M	L	M	L	M	L	M
		%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R	%R
			R		YR		Y		GY		G		BG		B		PB		P		RP	
		N9/	9/2	9/3	9/2	9/3	9/2	9/4	9/1	9/5	9/2	9/3	9/1	=	9/2	9/3	9/1	=	9/2	=	9/2	
9	78.7 I.C.I. A		72.7	73.2	73.0	73.3	76.5	70.3	71.6	74.3	70.5	71.0	69.4	73.5		72.4	70.7	72.0		72.3		75.5	
	I.C.I. B		72.6	72.3	71.7	72.7	74.2	69.5	68.1	74.2	70.4	72.1	71.1	74.0		73.9	72.7	72.2		72.1		74.7	
	I.C.I. C		72.6	72.0	71.2	72.0	73.3	69.1	66.4	74.1	70.2	72.4	71.6	74.2		74.1	73.4	72.3		71.9		74.5	
	M 7500 D		72.5																			
	Blue Sky S		72.5	71.2	70.0	75.3	70.4	68.0	61.1	73.8	69.2	73.4	73.1	74.6		75.4	75.5	72.6		71.8		73.9	
	Flu. 3500° K		72.6	72.7	72.3	78.7	76.0	70.1	72.2	74.3	71.2	71.7	70.4	73.7		72.9	71.5	71.8		71.7		74.6	
	Flu. 4500° K		72.6	72.4	71.8	77.9	74.8	69.7	70.0	74.2	71.0	72.1	71.1	73.9		73.6	72.4	72.0		71.7		74.4	
	Flu. 6500° K		72.6	72.0	71.2	77.0	73.3	69.2	67.3	74.1	70.7	72.6	71.9	74.2		74.4	73.5	72.2		71.7		74.2	
	Soft White		72.6	72.9	72.5	78.6	75.5	69.9	70.2	74.2	70.4	71.5	70.2	73.7		73.1	71.6	72.0		72.2		75.0	
			R		YR		Y		GY		G		BG		B		PB		P		RP	
		N8/	8/2	8/4	8/2	8/4	8/2	8/12	8/2	8/6	8/2	8/6	8/2	=	8/2	8/4	8/2	=	8/2	8/4	8/2	8/6
8	59.1 I.C.I. A		57.6	61.5	61.5	61.0	63.1	56.8	62.0	58.5	60.5	53.4	52.4	58.9		59.7	57.5	62.2		59.2	59.7	65.5	62.7
	I.C.I. B		57.5	60.6	59.4	59.7	60.7	56.0	58.6	58.6	60.5	56.6	55.1	60.3		61.2	59.5	63.3		59.0	59.4	64.6	61.1
	I.C.I. C		57.5	60.2	58.6	59.2	59.7	55.7	57.1	58.5	60.2	56.9	56.0	60.8		61.8	60.2	63.8		59.0	59.4	64.4	60.6
	M 7500 D		57.5	60.1	58.3	59.0	59.5	55.6	56.9	58.6	60.4	57.1	56.4	61.0		62.0	60.5	63.9		58.8	59.1	64.2	60.2
	Blue Sky S		57.4	59.1	56.7	57.8	56.9	54.7	51.7	58.3	59.0	57.9	58.3	62.2		63.5	62.5	65.4		59.2	59.8	63.7	59.5
	Flu. 3500° K		57.6	61.2	60.4	60.5	62.4	56.7	63.3	58.7	62.0	56.2	54.0	59.6		60.1	58.0	62.0		58.5	58.4	64.8	61.4
	Flu. 4500° K		57.6	60.7	59.5	59.9	61.2	56.3	60.9	58.7	61.6	56.6	55.1	60.2		60.9	59.0	62.7		58.6	58.7	64.5	60.9
	Flu. 6500° K		57.5	60.1	58.5	59.1	59.7	55.8	58.1	58.6	61.0	57.2	56.3	61.0		61.8	60.3	63.6		58.8	59.0	64.2	60.4
	Soft White		57.6	61.3	60.6	60.4	62.6	56.4	60.9	58.5	60.5	55.9	53.6	59.5		60.3	58.3	62.5		59.0	59.5	65.1	62.0
			R	R	YR	YR	Y	Y	GY	GY	G	G	BG	BG	B	B	PB	PB	P	P	RP	RP
		M7	7/2	7/8	7/2	7/10	7/2	7/10	7/2	7/6	7/2	7/6	7/2	7/4	7/2	7/6	7/2	7/6	7/2	7/6	7/2	7/8
7	43.1 I.C.I. A		44.2	47.0	47.7	45.6	48.9	45.5	45.6	42.6	43.0	41.0	40.2	45.5	43.7	45.5	46.8	47.7	43.1	41.3	44.8	48.5	51.4
	I.C.I. B		44.3	45.7	45.8	44.3	43.7	44.8	43.1	42.6	42.9	42.0	42.9	46.8	45.6	46.7	44.9	48.7	44.8	41.1	43.9	47.6	49.2
	I.C.I. C		44.3	45.2	42.4	43.8	41.8	44.5	41.9	42.6	42.6	42.3	43.8	47.3	46.3	47.2	44.4	49.1	45.6	41.1	43.8	47.3	48.4
	M 7500 D		44.3	45.0	41.8	43.6	41.3	44.5	41.8	42.7	42.8	42.5	44.2	47.5	46.6	47.3	44.6	49.1	45.7	41.0	43.4	47.1	47.9
	Blue Sky S		44.4	44.0	39.0	42.3	36.3	43.6	38.0	42.4	41.3	43.2	46.4	48.6	48.4	48.6	47.4	50.4	47.9	41.2	43.9	46.5	46.9
	Flu. 3500° K		44.3	46.3	45.3	45.2	47.0	45.5	46.2	42.8	44.8	41.6	41.5	46.0	44.4	45.8	43.3	47.6	42.9	40.7	42.9	47.9	49.5
	Flu. 4500° K		44.3	45.8	43.9	44.5	44.6	45.1	44.5	42.8	44.2	42.0	42.7	46.6	45.3	46.4	44.1	48.2	44.0	40.8	43.0	47.6	48.9
	Flu. 6500° K		44.3	45.1	42.1	43.8	41.7	44.6	42.4	42.7	43.5	42.5	44.1	47.4	46.4	47.2	45.7	48.9	45.3	40.9	43.2	47.2	48.1
	Soft White		44.3	46.4	46.0	45.0	46.6	45.2	44.6	42.6	43.1	41.4	41.3	46.0	44.5	46.0	43.7	48.0	43.7	41.2	44.1	48.1	50.4
			R	R	YR	YR	Y	Y	GY	GY	G	G	BG	BG	B		B	PB	PB	P	P	RP	RP
		N6	6/2	6/10	6/2	6/12	6/2	6/8	6/2	6/8	6/2	6/6	6/2	6/6	6/2		6/6	6/2	6/8	6/2	6/8	6/2	6/10
6	30.6 I.C.I. A		30.3	33.4	38.7	32.7	38.9	32.9	34.1	32.5	32.6	29.1	27.1	32.7	31.4	30.7	27.4	33.4	30.6	32.6	32.3	32.6	38.1
	I.C.I. B		30.3	32.4	34.0	31.6	34.2	32.4	32.3	32.5	32.6	30.0	29.6	33.9	33.8	31.9	30.2	34.0	32.3	32.4	31.6	31.9	34.9
	I.C.I. C		30.2	32.0	32.4	31.2	32.4	32.1	31.4	32.4	32.4	30.3	30.4	34.3	34.7	32.3	31.3	34.3	33.1	32.4	31.6	31.7	33.9
	M 7500 D		30.3	31.9	31.5	31.2	32.0	32.1	31.5	32.5	32.5	30.5	30.7	34.4	35.0	32.4	31.5	34.4	33.2	32.3	31.2	31.6	33.1
	Blue Sky S		30.3	31.1	28.3	30.0	27.4	31.3	28.6	32.3	31.5	31.1	32.8	35.6	37.4	33.7	34.7	35.3	35.6	32.5	31.9	31.1	31.7
	Flu. 3500° K		30.4	32.9	35.6	32.4	37.2	33.0	34.8	32.7	33.7	29.6	28.1	33.0	32.0	31.0	27.7	33.3	30.4	32.1	30.5	32.2	35.3
	Flu. 4500° K		30.4	32.5	33.9	31.9	35.0	32.6	33.4	32.7	33.3	30.0	29.3	33.6	33.3	31.6	29.2	33.7	31.5	32.1	30.7	31.9	34.4
	Flu. 6500° K		30.3	32.0	31.9	31.2	32.3	32.2	31.8	32.6	32.9	30.4	30.6	34.3	34.8	32.3	31.1	34.2	32.8	32.2	31.0	31.6	33.4
	Soft White		30.3	33.0	36.7	32.2	36.8	32.7	33.4	32.5	32.6	29.5	28.1	33.1	32.4	31.2	28.5	33.6	31.2	32.5	31.9	32.3	36.8

1. (L) for "Low" chroma (/2 whenever available); (M) for "Maximum" chroma (this varies according to the degree to which each extends).
2. Maximum sample same as minimum.

version table of the sort given just above, is something that any illuminating engineer will find useful.

Reflectances for three illuminants are given for each sample on the Munsell value-reflectance charts. Since these charts were developed, I.C.I. data have been obtained on the samples used in the charts for five additional illuminants.[2] The I.C.I. reflectance-data (Y-data) for these samples viewed under these eight luminators, and for Macbeth 7500K, are given in Table I.

Table I provides much detailed information. As may be seen from this table, the neutral grays retain approximately the same reflectance under all illuminants. If they were absolutely non-selective in their spectral characteristics they would be absolutely, instead of approximately, the same. The low chroma colors change only slightly under change of illuminant color; the maximum chroma colors show the greatest change, some hues changing more than others.

There are also changes in hue and chroma under change of illuminant. Aesthetically such changes may be more important than those in reflectance.[3] However, while the over-all color change may be the subject of later reports, in this report the discussion is limited to value and its relation to reflectance.

[2]Full I.C.I. data will soon be published for approximately 500 Munsell samples for these illuminants.

[3]Conversion of threefold psychophysical color measurements to color appearance in terms of threefold psychological color scales for colors seen under different illuminants are not yet available except in a fragmentary way. Although I.C.I. data will soon be available for a series of reference standards under nine different illuminants, much observational work of the type being done under Harry Helson at Bryn Mawr remains to be completed before the equations proposed by D. B. Judd of the National Bureau of Standards will supply accurate conversions for specifications of the entire color change in a sample as it is seen under different illuminants.

Theoretical			N	R		YR		Y		GY		G		BG		B		PB		P		RP	
Value	%R	Illuminant	%R	L %R	M %R	L %R	M %R	L %R	M %R	L %R	M %R	L %R	M %R	L %R	M %R	L %R	M %R	L %R	M %R	L %R	M %R	L %R	M %R
			N5/	R 5/2	R 5/12	YR 5/2	YR 5/10	Y 5/2	Y 5/6	GY 5/2	GY 5/8	G 5/2	G 5/8	BG 5/2	BG 5/6	B 5/2	B 5/6	PB 5/2	PB 5/10	P 5/2	P 5/10	RP 5/2	RP 5/10
5	19.8	I.C.I. A	19.0	20.8	26.0	20.4	24.6	21.8	21.0	21.0	21.0	18.1	16.3	19.6	18.0	18.1	16.3	20.1	19.7	19.8	21.3	22.2	27.2
		I.C.I. B	19.1	19.9	21.0	19.6	21.7	21.4	20.3	21.0	21.1	18.7	18.1	20.5	20.2	18.9	18.5	20.6	21.7	19.6	20.5	21.6	24.0
		I.C.I. C	19.1	19.5	19.4	19.3	20.6	21.2	19.8	21.0	21.0	18.9	18.8	20.8	21.0	19.2	19.4	20.9	22.6	19.6	20.4	21.4	23.0
		M 7500 D	19.1	19.4	18.2	19.2	20.3	21.2	19.9	21.0	21.1	19.0	19.0	20.9	21.2	19.2	19.6	20.9	22.8	19.5	20.0	21.2	22.2
		Blue Sky S	19.1	18.6	15.4	18.4	17.4	20.6	18.2	20.8	20.4	19.4	20.7	21.7	23.5	20.1	22.2	21.6	25.5	19.6	20.5	20.9	20.7
		Flu. 3500° K	19.1	20.3	21.9	20.1	23.6	21.8	21.8	21.2	22.0	18.4	16.8	19.8	18.2	18.2	16.4	20.1	19.6	19.4	19.5	21.8	24.3
		Flu. 4500° K	19.1	19.9	20.4	19.8	22.2	21.6	21.0	21.2	21.8	18.7	17.8	20.3	19.4	18.6	17.6	20.4	20.8	19.4	19.6	21.6	23.4
		Flu. 6500° K	19.1	19.5	18.7	19.3	20.5	21.2	20.0	21.1	21.5	19.0	18.9	20.8	20.9	19.1	19.2	20.8	22.3	19.5	19.8	21.3	22.5
		Soft White	19.1	20.4	23.5	20.0	23.3	21.6	20.9	21.0	21.1	18.3	17.0	19.9	18.8	18.4	17.1	20.3	20.5	19.7	20.7	22.0	25.6
			N4/	R 4/2	R 4/14	YR 4/2	YR 4/8	Y 4/2	Y 4/4	GY 4/2	GY 4/6	G 4/2	G 4/4	BG 4/2	BG 4/6	B 4/2	B 4/8	PB 4/2	PB 4/10	P 4/2	P 4/12	RP 4/2	RP 4/12
4	12.0	I.C.I. A	12.1	13.8	18.8	13.7	15.8	14.6	13.2	13.5	12.5	12.2	11.7	12.9	11.5	12.8	9.5	12.7	12.2	12.6	14.7	15.1	17.3
		I.C.I. B	12.1	13.0	14.7	13.0	14.2	14.3	12.7	13.6	12.5	12.7	12.6	13.6	13.0	13.5	11.0	13.0	13.8	12.5	12.7	14.6	14.7
		I.C.I. C	12.1	12.8	13.3	12.7	13.5	14.2	12.4	13.6	12.5	12.8	12.9	13.8	13.5	13.7	11.7	13.1	14.5	12.5	13.4	14.4	14.0
		M 7500 D	12.1	12.7	12.3	12.6	13.5	14.2	12.5	13.6	12.6	12.9	13.0	13.9	13.7	13.8	11.8	13.6	14.6	12.4	12.9	14.4	13.2
		Blue Sky S	12.1	12.1	10.2	11.9	11.7	13.8	11.6	13.5	12.2	13.2	13.8	14.6	15.4	14.6	13.8	13.6	16.7	12.5	13.1	14.1	12.2
		Flu. 3500° K	12.1	13.4	15.0	13.4	15.4	14.7	13.4	13.7	12.9	12.4	12.0	13.1	11.8	12.9	9.4	12.7	12.0	12.4	11.8	14.7	14.4
		Flu. 4500° K	12.1	13.1	13.9	13.1	14.6	14.5	13.0	13.7	12.8	12.6	12.5	13.4	12.6	13.2	10.3	12.9	13.0	12.4	11.8	14.6	13.9
		Flu. 6500° K	12.1	12.8	12.6	12.7	13.5	14.2	12.5	13.6	12.7	12.9	13.0	13.8	13.6	13.7	11.5	13.1	14.1	12.4	11.9	14.4	13.3
		Soft White	12.1	13.5	16.5	13.4	15.1	14.5	13.0	13.6	12.5	12.4	12.0	13.2	12.2	13.0	10.0	12.8	12.8	12.6	12.8	14.9	15.7
			N3/	R 3/2	R 3/10	YR 3/2	YR 3/4	Y 3/2	*	GY 3/2	GY 3/4	G 3/2	G 3/4	BG 3/2	BG 3/6	B 3/2	B 3/6	PB 3/2	PB 3/12	P 3/2	P 3/10	RP 3/2	RP 3/10
3	6.55	I.C.I. A	6.5	7.8	9.9	7.6	9.0	7.1		7.5	7.4	6.6	7.2	6.6	6.4	6.6	6.4	6.6	6.3	7.5	8.4	7.0	9.3
		I.C.I. B	6.5	7.3	8.6	7.2	8.1	7.0		7.5	7.4	6.9	7.8	7.1	7.3	7.0	7.6	6.8	7.5	7.4	7.8	6.6	7.9
		I.C.I. C	6.5	7.2	7.4	7.0	7.8	6.9		7.5	7.4	7.0	8.0	7.3	7.7	7.2	8.0	6.9	8.0	7.4	7.7	6.5	7.4
		M 7500 D	6.5	7.1	7.0	6.9	7.8	6.9		7.5	7.4	7.1	8.1	7.3	7.8	7.1	8.1	6.9	8.1	7.3	7.5	6.5	7.0
		Blue Sky S	6.5	6.7	6.0	6.5	7.0	6.7		7.4	7.3	7.4	8.7	7.8	8.9	7.6	9.5	7.2	9.8	7.4	7.6	6.3	6.4
		Flu. 3500° K	6.5	7.5	8.2	7.4	8.7	7.1		7.6	7.6	6.7	7.4	6.7	6.3	6.6	6.3	6.6	7.3	7.3	7.3	6.7	7.6
		Flu. 4500° K	6.5	7.3	7.7	7.2	8.3	7.0		7.6	7.5	6.9	7.7	7.0	6.9	6.9	7.0	6.7	7.9	7.3	7.3	6.6	7.3
		Flu. 6500° K	6.5	7.1	7.1	7.0	7.8	6.9		7.5	7.4	7.1	8.1	7.3	7.6	7.1	7.8	6.9	9.1	7.3	7.3	6.5	7.0
		Soft White	6.5	7.6	8.9	7.4	8.6	7.0		7.5	7.4	6.7	7.4	6.8	7.7	6.8	6.8	6.7	8.6	7.4	7.9	6.8	8.2
			N2/	R 2/2	R 2/6	YR 2/2	*	Y 2/2	*	GY 2/2	*	G 2/2	*	BG 2/2	BG 2/4	B 2/2	*	PB 2/2	PB 2/6	P 2/2	P 2/6	RP 2/2	RP 2/6
2	3.13	I.C.I. A	3.0	4.4	5.6	4.7		4.9		4.6		3.5		3.5	3.4	3.5		3.3	3.4	3.9	3.7	4.2	5.2
		I.C.I. B	3.0	4.1	4.8	4.5		4.8		4.6		3.7		3.7	3.8	3.7		3.4	3.8	3.5	3.5	3.9	4.6
		I.C.I. C	3.0	4.0	4.6	4.4		4.7		4.6		3.7		3.8	4.0	3.8		3.5	4.0	3.8	3.5	3.9	4.4
		M 7500 D	3.1	3.9	4.4	4.4		4.7		4.6		3.7		3.8	4.0	3.8		3.5	4.1	3.7	3.4	3.8	4.2
		Blue Sky S	3.0	3.7	4.0	4.2		4.6		4.6		4.0		4.1	4.4	4.1		3.8	4.8	3.8	3.4	3.7	4.0
		Flu. 3500° K	3.0	4.2	5.0	4.6		4.8		4.6		3.5		3.4	3.4	3.5		3.3	3.3	3.5	3.4	4.0	4.5
		Flu. 4500° K	3.0	4.1	4.8	4.5		4.8		4.6		3.6		3.6	3.6	3.6		3.4	3.6	3.5	3.4	3.9	4.4
		Flu. 6500° K	3.0	4.0	4.5	4.4		4.7		4.6		3.7		3.8	3.9	3.8		3.5	3.9	3.5	3.4	3.8	4.2
		Soft White	3.0	4.3	5.2	4.6		4.8		4.6		3.5		3.5	3.5	3.6		3.4	3.5	3.6	3.5	4.0	4.8
			N1/																				
1	1.21	I.C.I. A	1.5																				
		I.C.I. B	1.5																				
		I.C.I. C	1.5																				
		M 7500 D	1.5																				
		Blue Sky S	1.5																				
		Flu. 3500° K	1.5																				
		Flu. 4500° K	1.5																				
		Flu. 6500° K	1.5																				
		Soft White	1.5																				

Lighting A High Press Shop

By GEORGE N. MEYERS

SAFETY, production and efficient handling of stock are the first considerations in the lighting of a press shop. There are other considerations, however, which while secondary are nevertheless important. In making a completely new installation, for instance, it is more economical to design one system to meet all basic requirements rather than to attempt to solve each problem independently.

Outside of the press itself, the lighting problems to be considered are:

(1) Trucking and pedestrian traffic in the main aisles.

(2) Preparatory operations such as processing raw stock in roller levelers, shearing, etc.

GEORGE N. MEYERS is an electrical engineer with the Budd Company, Philadelphia, Pa.

The fundamental job of lighting in a press shop is to provide good illumination in and around the lower die. Safety is the first consideration; production is the second, and efficient handling of raw stock and fabricated pieces is the third. All other items are secondary.

(3) Selection, moving, and inspection of raw stock in local storage areas.

(4) Trucking and placement of raw materials within reach of the pressmen.

(5) Greasing of individual sheets just prior to forming.

(6) Handling of partially completed blanks from one press to an adjacent press in the same line-up.

(7) Local annealing stations between presses.

(8) Inspection of the fabricated parts at various stations along the line.

Figure 1. Typical incandescent lighting system in a high press shop.

(9) Maintenance service—lubrication, minor adjustments, equipment inspections, etc.

(10) General crane operations, carrying of dies, press parts and steel stock.

In the relighting job described, the original system was installed when the building was erected in 1916. It consisted of shallow, open type white enamel reflectors similar to present day R.L.M.'s. In the high bay area two rows of fixtures were spaced 40 feet apart, each equipped with 1,000-watt lamps at 25-foot intervals. The medium bay areas used two rows of fixtures 15 feet apart with 500-watt lamps every 25 feet.

Several fixtures were included in a circuit and then wired through conduit to a centrally located distribution panel. The panel contains 30 open type two-pole fused switches, one for each lighting circuit. The main feed to the panel consists of three 4/0 conductors running to a 400-ampere fused switch in the substation.

Analysis of Lighting Problems

What are the things the worker must see? Before pressing the "run" button, the operator must assure himself that everything is clear inside the press and that his three helpers are in safe positions. The pressmen must watch the upper ram descend so that press motion can be stopped if necessary.

After the precise and complicated operation of fabrication, check inspection of stampings between the various pressing stations is frequently done to detect quickly units causing scratches, etc. This is of particular importance after a change of dies.

Frequently the internal stresses in the partially completed stamping must be relieved before the next press operation, otherwise the steel may split. To release these stresses the stampings are stacked in piles, heated to cherry red, slowly cooled, and then passed to the next press in the line-up.

Storage, trucking and placement of raw steel presents difficulties in handling problems, most of which is done during working hours and requires good visibility. Men moving these heavy loads must quickly see new obstructions, particularly in close quarters between presses. Careful blocking and stacking of blank sheets is absolutely necessary as the oil between sheets makes them very slippery and dangerous to handle.

Periodic lubrication, die adjustments and fre-

Figure 2. Mercury lighting system in similar plant area (see Figure 1).

quent equipment inspections are made by the operating forces during production periods.

Die changes and major repairs are made on individual presses during production hours. This requires groups of men working on individual sections of the press simultaneously, such as pipefitters, electricians and millwrights.

Several independent cranes operating on a single track require good visibility to prevent accidents. Close clearance between the top of presses and bridge of the crane limit all longitudinal carries to the center aisle, while transverse travel must be done in the limited space between presses. The crane operator must be able to spot quickly his "hook," judge clearances and warn personnel being approached.

Color of surrounding surfaces is also an important factor in the visual environment of such industrial areas. In the shop described the working area inside the press walls is light grey, while the die itself is polished steel. The material being fabricated is slightly darker than the die and some contrast is therefore present.

The walls and ceiling of the shop are painted white, while the wood floor is black. The shop contains a high bay flanked by two medium bays.

Control and Maintenance Problems

Previous experience indicated that the location of lighting switches is very important, particularly in shops where press rearrangements are frequently made. Existing panels had been previously fastened to building walls along former aisles. These locations are no longer favorable due primarily to the increased use of conveyor systems, which frequently are run along walls so that open floor areas will remain clear for production machines; hazards are consequently created by objects on the conveyor to persons turning on the lights. The danger of a panel door being occasionally left open and catching on material hanging from the conveyor is also important. The location of new panels should permit access from at least two directions, preferably on a column located near a permanent aisle. The number of panels must be kept to a minimum, but the distance between them should not exceed 100 feet.

Reliability of service is a big factor in a production shop. Every consideration must be given to planning a system that will automatically isolate a defective unit and permit it to be de-energized and worked on independently. At the same time all working parts must be readily accessible to the electrician, but inaccessible to production workers.

Solution of Lighting Problem

Light sources available for large shops include: 1. Incandescent; 2. Fluorescent (hot cathode); 3. Fluorescent (cold cathode); 4. Mercury (3-kw); 5. Mercury (400-watt).

Incandescent lamps would do a very good lighting job, but their lumen output per watt is felt to be relatively low. In order to provide a sufficiently high illumination level, the source of power, main feeders, operating costs, etc., would be more costly than with other sources.

Fluorescent units are designed to give maximum efficiency when mounted at low or medium heights. The number of fixtures needed to furnish the required light output would be quite high, necessitating an expensive distribution system. The maintenance cost of many small light sources is also considered excessive with this source, for large shop installations.

Three-kilowatt mercury lamps have high intensity outputs and are well adapted to high bay usage. The life expectancy of each lamp is longer than incandescent and as the number of fixtures required is considerably less than other light sources, lamp burn-outs are fewer. One objection to this lamp in installations is the green cast imparted to objects. Another is the fact that after a momentary interruption, several minutes must elapse before the arc can be re-established.

The 400-watt mercury lamps have characteristics similar to the 3-kw unit, except that they are smaller in size and are designed for medium bay mounting.

There are a number of reasons for selecting mercury as a light source for shop operations. In the first place minimum mounting height in the high bay is approximately 35 feet, so that the incandescent or mercury units would be the best types to use. (Fluorescent units mounted as supplementary lighting could do the job but they would obstruct crane operations.) With incandescent lumen output per watt about half that of mercury, sub-station facilities together with the main feeder would be halved with the use of mercury.

Incandescent lamps of 1,000 watts are the largest commonly used, so only one-sixth as many fixtures would be required for 3-kw mercury. Similar ratios exist for the medium bays where 500-watt incandescent lamps are used. Each mercury lamp has four times the life expectancy of the incandescent lamp. For 24 incandescent burnouts there would only be one for mercury. The monthly power bill for a given incandescent output is reduced approximately 50 per cent when mercury is used instead.

Characteristics of Reflectors*

The 400-watt mercury reflectors used in the medium-bay area are of the porcelain enameled, medium-bay type, with the glass dust cover assembly built in as an integral part of the unit. Rugged equipment of this type is essential for heavy press shop operating conditions.

The 3-kw mercury tube as a light source was receiving considerable attention by industry at this time for lighting high-bay areas. The selection of reflectors for this lamp was limited and those available were of such small dimensions that their overall brightness was excessively high. It was felt that the high brightness reflected in the sheets of steel would be distracting to the workers. A new reflector was therefore designed to eliminate this objection as far as possible, and which included the following specifications:

(1) Large area — lower brightness

(2) High efficiency — easy maintenance

(3) Minimum shielding angle of 30 degrees

(4) Rugged construction

(5) Sockets — ventilated, safety lamp holders, readily accessible for lamp replacement

The new reflector met all these requirements. Its contour is in the form of an involute of a circle, designed for no inter-reflections and no multiple reflections when made of specular material (Alzac aluminum). It is large in size — more than 60 inches long, 30 inches in width, and 12¾ inches high, but these dimensions were necessary to achieve our major objective, namely *lower brightness.*

Specular aluminum (Alzac) was not available when these units were manufactured. Sheet steel was used instead and finished with a high reflectance aluminum paint. Porcelain enameling was found to be impractical as the reflector was drawn out of contour by the high temperature necessary to fuse the enamel. Reflectors manufactured today are finished with a white silicone enamel which has been found superior to the aluminum paint.

Below the cut-off angle the unit has a low brightness appearance similar to that which would be obtained by covering the bottom of the reflector with a diffusing glass cover.

The Lighting Layout

The high bay area is 60 feet wide and 500 feet long, and each side bay is 30 feet wide and the same length as the high-bay. This area is subdivided by cross-trusses into sections 60 feet wide and 25 feet long. The 3-kw fixtures are mounted 15 feet from the edge of the building, along the center line of each bay, in addition to the existing 1,000-watt incandescent units. Across the bay the spacing is 30 feet, while down the shop they are spaced 25 feet, thus each fixture covers 750 square feet. Medium-bays are 30 feet wide by 25 feet long. One single 400-watt and two twin 400-watt units are mounted in each bay, plus the existing 500-watt incandescent fixtures. The twin units are 5 feet from the walls while the single unit is in the center of the bay.

The four push button panels are all located on one side of the room. Spaced 100-feet apart, each controls the full width of the building for a distance of 50 feet in both directions.

There are two main press lines in the high bay area, with one press line in each of the two medium bays. The high bay area has a large center aisle for trucking, crane travel, and pedestrian traffic. Three 15-ton cranes operate on a single overhead track. Fixtures are serviced from the top of the crane bridge. The serviceman can independently de-energize, repair, or test any circuit from the craneway, as all switches, relays, and feeders are mounted along the craneway catwalk.

Wiring Layout

Three 500-kva 13200/240v single phase transformers furnish lighting service to the shop. Provision has been made to supply adjacent areas with lighting service at some future date. Three-phase six-wire service has been extended the full length of the shop. Each leg consists of three 500-mcm cables and reduces to two per leg in the middle of the building. Tapping blocks are provided in strategically located junction boxes to pick up existing and future loads. This feeder is located along the craneway and in an isolated protected area. Future additional loads can easily be installed without any changes in the present set-up.

Each 3-kw fixture is fed by a step-up transformer which is in turn supplied by a two pole 22.5-ampere contactor tapped on the main feeder through a 30-ampere fused safety switch. One thousand-volt #12 wire is used between the fixture and its transformer while 600-volt #8 is used for the remaining feeds. Control wiring is 600-volt #14. Momentary push button control switches are used to prevent accidental re-energization of the transformer while working on the unit. These buttons are grouped six in a panel, with the panels mounted every 100 feet up the main floor.

The 400-watt fixtures are similarly wired except that each bay is on one circuit. The five lamps are fed from a common #12 line to a contactor, thence to a safety switch. The line side of

*Reflector designed by G. W. Wagner, Philadelphia Electric Co.

the safety switch is fed by #8 wire as the adjacent bay is also taken off the same feed.

Each fixture or group of fixtures has been wired so that at least one adjacent fixture or group is on another phase, to minimize stroboscopic effect. This staggering of phases has been very successful. Furthermore, in the event of 500-kva transformer failure, sufficient light will be available in all areas to maintain full production.

Results

In the initial installation, incandescent lamps in this area provided an average general illumination value of 5 footcandles. This value decreased as one approached the press, due to adjacent presses cutting off the light from distant sources. At a depth inside the press of 12 inches, the illumination was reduced to 2.5 footcandles, and along the center line of the die it dropped to 0.5 footcandle. Good lighting practice requires that a minimum of 10 footcandles be maintained at least 2½ feet inside the press frame (frame depth 6 feet). The existing illumination therefore was inadequate according to present standards.

Tests made upon completion of the new installation indicated that the general illumination was raised from 5 ft-c to 55 ft-c or 1,100 per cent. Along the edge of the press the illumination increase was from 3.2 to 40 footcandles, while at a distance of one foot inside the housing the ratio was 2.5 ft-c to 15 ft-c or 600 per cent. Along the center line 0.5 ft-c was raised to 2.5 ft-c or 500 per cent.

Conditions at the end of two years' service showed that during the two years' operation of the mercury units, there has not been a single complaint regarding illumination in the entire shop, nor has there been any service interruptions of any consequence. The average 3-kw tube life exceeds rated expectancy and, when they do burn out, replacements are very easily made. The white reflecting surfaces did not retain their glossy surfaces due to the poor quality of the enamel available at that time.

In general, the present output is operating at a normal maintenance factor, and everyone is satisfied with the results obtained. Recent test results are as follows:

General illumination on floor	40 ft-c
Along edge of press	24 ft-c
Inside housing 12 inches	9 ft-c
Inside housing along center line	2 ft-c

Conclusion

The only major disadvantage of this lighting system is the color distortion. The greenish cast imparted to complexions is noticeable during the first few days. This objection soon wears off, however, as one becomes accustomed to it, but the use of mercury in areas where women predominate might be a serious factor. The color distortion can, however, be overcome to some extent by the interspacing of incandescent units for color correction.

We retained the existing incandescent system not only for the slight color correction obtained, but as an additional safety feature. Mercury lamps cannot be relighted instantly as they require 6 to 8 minutes to cool before the arc restrikes. During this period the incandescent units will provide some general illumination in the event a momentary service interruption occurs. We also use the old system for night lights during non-productive hours.

A brief summary of advantages attained by the new system include:

(1) Better visibility.

(2) Reduced operating fatigue.

(3) Elimination of temporary cords and special fixtures.

(4) Operators enabled to gauge distances better and observe all motions of helpers, reducing accidents to a minimum.

(5) Inspection of stampings possible immediately before and after forming operations, thus reducing number of final rejects.

(6) Lighting maintenance costs kept at a minimum.

(7) Power required is half that for an equivalent incandescent installation.

This lighting installation was of particular interest to me because we knew that a decided improvement in press shop working conditions could be made at a moderate capital expenditure. The diversity of work performed in this area, together with the geometry of the building and its equipment, required careful consideration of many factors not encountered in routine assignments.

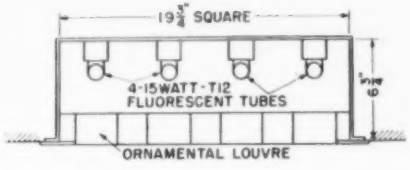
The utilization of existing available sub-station equipment and the providing of a main feeder capable of handling future expansion was very important to us.

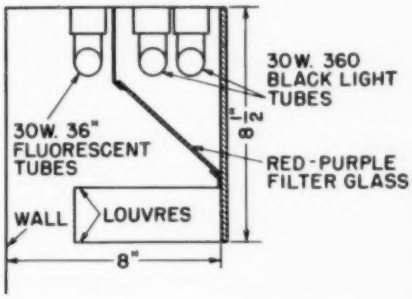
Aside from the actual granting of funds, detailing the layout, and ordering material, one of the most important phases of this job was coordinating the activities of the electrical contractor and the production shop superintendent. Most of the overhead work had to be performed from the bridge of the shop crane. Production work and die setting continued on all shifts during the installation, therefore tying up cranes was a major consideration throughout the entire job.

Lighting of a Leisure Room

LIGHTING OBJECTIVE: To illuminate a room for recreation, leisure and dramatic appeal.

Installation at Philadelphia, Pennsylvania





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General Information: The room is 17 feet by 15 feet with an 8 foot 8-inch ceiling. The design is modern. The furniture is pickled oak and the upholstered pieces are American Beauty red and Kelly green. The rug is black. Two of the walls are painted light green and the other two are covered with wallpaper which has a silver background with a light and dark green figure which has been treated with fluorescent paint. It was desired to incorporate a low level of lighting for conversation and television as well as to illuminate those areas where seeing tasks such as card playing and reading are done. Beside a reading chair (in corner not shown) a floor lamp was used. As an additional effect it was desired to use black light for dramatic appeal.

Installation: Cornices to conceal a single row of 30-watt, 36-inch fluorescent lamps and a double row of 30-watt, 36-inch black light lamps are used on opposite walls. The rows of black light lamps are covered with a strip of red-purple glass to filter out the visible light. All three rows of lamps are shielded by a metal louver.

Inasmuch as a room of this decor would not be used for seeing tasks more exacting than card playing and periodic reading, the illumination is mostly decorative. For exciting dramatic appeal the fluorescent wallpaper becomes luminous when activated by black light and produces enough background lighting when viewing television.

The card table has its own fixture mounted above the table. This unit is 19¾ inches square and houses four 15-watt (3500°K) fluorescent lamps. This fixture is recessed into the ceiling and has an ornamental cross-bar louver to conceal the lamps. The four corners of the fixture are decorated with hearts, diamonds, spades and clubs to add to its appropriateness. This fixture produces 24 footcandles on the card playing surface. The fixture is custom-made by Voight Company, Philadelphia, Pennsylvania, Catalog No. 10122.

Lighting data submitted by Miss Myrtle Fahsbender, Director of Residential Lighting, Lamp Division, Westinghouse Electric Corporation, Bloomfield, New Jersey, as an illustration of good lighting practice and to suggest ideas that may be used in similar installations.

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Comparison of Argon and Krypton As A Filling Gas in Fluorescent Lamps

By CLIFTON G. FOUND
W. J. WINNINGHOFF

The light output and efficiency of a fluorescent lamp are dependent on a large number of factors, such as its physical dimensions, the current through the lamp, the temperature of the location in which the lamp is operated, the increase in bulb temperature above ambient, and the kind and quantity of the filling gas. Normally these factors are not independent of each other. The present paper is an attempt to separate some of the interdependent variables and show how they influence the light output and efficiency.

THE VAPOR pressure of mercury is determined by the temperature of the liquid mercury in the lamp. Since in a short time the mercury from the warmer parts of the lamp will evaporate and condense at the point of lowest temperature, the latter will determine the vapor pressure of mercury in a lamp operated under steady state conditions. This temperature will depend on the size and wattage of the tube and the ambient temperature under normal operating conditions.

Effect of Mercury Vapor Pressure

The light output can be measured as a function of the mercury vapor pressure in the following manner. A tube of fixed dimensions and conducting a given current can be immersed in a water bath, thereby maintaining a definite wall temperature. By varying the temperature of the water, the light output can be measured as a function of the wall temperature. The vapor pressures corresponding to the different temperatures can be obtained from a table.

Results of such a series of measurements on a 48-inch T12 F lamp (fluorescent lamp 48 inches long and 1.5 inches diameter) operating at 0.4 amp are shown in Fig. 1. The curve shows that the light output passes through a maximum at a wall temperature of 38°C which corresponds to a mercury vapor pressure of about five microns. It will also be noted that the temperature can be varied from 30°C to 48°C without decreasing the light output by more than five per cent of the optimum value.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Boston, Mass., September 20-24, 1948.

CLIFTON G. FOUND and W. J. WINNINGHOFF are with the General Electric Co., Lamp Development Laboratory, Nela Park, Cleveland, Ohio.

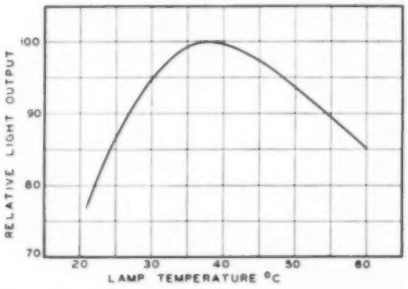


Figure 1. Relative light output as a function of bulb wall temperature.

Light Output as Function of Current at Constant Pressure

The relation between current and light output at constant mercury pressure can be obtained in a similar manner by operating the lamp in a constant temperature water bath. An alternative method of obtaining the same results is to bring the lamp to thermal equilibrium at a definite input wattage and then quickly increase or decrease the current before the temperature of the lamp has time to change. In using this method the lamp should be brought back to its original thermal equilibrium before each measurement.

The results of such an experiment are given in Fig. 2 in which the lumens, lumens per watt in arbitrary units, and volts are plotted as a function of the current at a wall temperature of 45°C. The plot contains data for two sets of lamps; the dotted curves are for lamps filled with Ar at a pressure of 2 mm, and the solid curve for lamps in which the Ar pressure was 7.5 mm. It will be

noted that the lumens do not increase linearly with current and as a result the efficiency decreases as the current is increased. Another observation is that, under these conditions, the lumens are practically independent of the pressure of Ar while voltage increases and the efficiency decreases considerably as the Ar pressure is increased. The effect of Ar pressure is discussed more fully in the following section.

Of course, relations shown in Fig. 2 are only of academic interest since in normal operation the bulb temperature, and hence the mercury pressure, increase as the current is increased. However, a knowledge of the output as a function of pressure and current as independent variables is of great value in lamp design and in the interpretation of lamp behavior under different conditions of operation.

Effect of Argon-Filling Pressure

In the present fluorescent and bactericidal lamps, argon is used as a filling gas. This gas serves two purposes. It facilitates starting and permits the lamps to operate with a cathode drop which is below the disintegration voltage.

In the 48-inch T12 40-watt fluorescent lamp the nominal argon-filling pressure is 3.5 mm. If the pressure is reduced much below this, the lamp life is shortened because of an increase in cathode drop at low gas pressure. On the other hand, if the filling pressure is increased above 3.5 mm, there is a decrease in lamp efficiency. The decrease in lamp efficiency for a lamp of a given physical dimension is due to an increased voltage drop in the lamp which accompanies the increase in argon pressure.

The relation between argon pressure and lamp voltage for 48-inch T12 lamps at 0.42 amp is shown graphically in Fig. 3. The curve shows an increase in lamp voltage of about seven volts per millimeter increase of argon pressure. The spread of lumen output of the lamps at constant current for the range of pressures shown was no greater than the spread for lamps made at a fixed pressure.

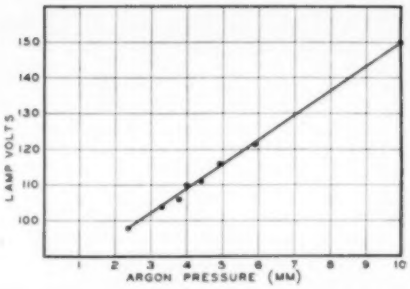


Figure 3. Relation between lamp volts and Ar pressure for 48-inch T12 lamps.

These investigations and others indicate that the light output of the fluorescent lamp at constant mercury pressure and constant current is independent of the pressure of the filling gas. The increase in voltage of the lamp with increase of filling pressure also indicates that a considerable amount of energy consumed by the lamp is consumed by the argon filling. Since the large majority of the electrons in the discharge are incapable of ionizing or exciting the argon gas, the only type of collisions which they can have with the argon are elastic collisions. Although the energy lost by an electron when it collides with an argon atom is a very small fraction of its energy before the collision, there are such a large number of such collisions that the total adds up to an appreciable amount.

Energy Conversion in 40-watt Fluorescent Lamp

Analysis indicates that in the 40-watt lamp with 3.5 mm argon-filling pressure, approximately 20 per cent of the 40 watts, *i.e.*, 8 watts, is lost to the argon by elastic collision. Analysis also shows that the remaining 32 watts are divided as follows:

(1) The energy required to get the current into the discharge and out of the discharge, termed "electrode loss," amounts to about 6 watts.

(2) Ions and electrons recombine on the wall and must be replenished. This is the power consumption which is essential to permit the current to pass through the discharge column, and in the 40-watt lamp amounts to slightly less than one watt. Energy of the electrons in the discharge adjusts itself to a value which is just sufficient to compensate for the ion and electron losses to the wall.

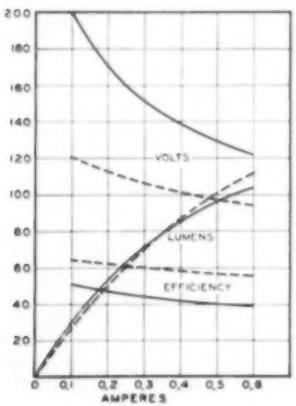


Figure 2. Lamp characteristics as a function of current at two pressures of A R (dashed, 2mm; solid, 7.5mm).

(3) When equilibrium of wall losses and ion generation is reached, the energy of the greater proportion of the electrons is below the minimum excitation and ionizing potential of the filling gas. These are however able to excite mercury vapor, producing 22 watts of 2537A which excites the fluorescent material to produce visible radiation, 2 watts of 1849A, and about one watt of visible radiation.

It was pointed out above that the fraction of its energy that an electron loses in colliding with a gas atom is very small. It is also known that the heavier the gas atom the smaller is this fraction. In fact, it is inversely proportional to the mass of the gas atom. Consequently, if a heavier gas could be substituted for argon, less energy would be lost by the electrons to the filling gas. For example, if krypton were used instead of argon, the energy lost to the krypton at the same filling pressure would be approximately one-half of that lost to the argon. This statement assumes that the collision cross sections of the argon and krypton atoms are the same. Use of a heavier filling gas also permits use of a lower pressure of that gas. This results from the fact that ions produced in the vicinity of the cathode from the heavier filling gas move more slowly than those from the lighter filling gas and do, consequently, more effectively counterbalance the electron space charge, and hence keep the cathode drop low. Not only are the heavier ions more effective in counteracting the electron space charge but in general are also easier to produce.

Effect of Kind of Filling Gas

When Kr at a pressure of 2 mm is used instead of 3.5 mm of Ar in a 48-inch T12 fluorescent lamp, it is found that the lamp voltage at a given current is much lower in the case of Kr and as a result the wattage, and therefore the vapor pressure of mercury, is also lower. Another way of expressing the same relation is that in order to maintain the same wattage with Kr, the lamp must operate at a higher current. The instantaneous relation between lumens, lamp volts, watts, and lumens per watt with current is shown in Fig. 4 for lamps filled with 2 mm of Kr (dashed curves) and those filled with 3.5 mm of Ar and stablized at 45°C, which means constant vapor pressure of Hg.

It will be observed from the curves that the light output at a given current is practically the same for the Ar- and Kr-filled lamps but that the voltage of the Kr lamp is considerably lower than that of the Ar lamp. At 0.42 amp the voltages are 104 for Ar and 84 for Kr. Consistent results were obtained for a Ne-filled lamp in which case the light output was again practically the same as for Ar and Kr but with 3.5 mm Ne at 0.42 amp the voltage was about 150 volts. These results lead to a generalization, which holds only to a first approximation, namely, that, at constant Hg pressure, the light output is independent of the kind and quantity of the filling gas. This generalization indicates that the light output depends only on the vapor pressure of Hg and the current through the lamp, while the voltage drop and therefore wattage of the lamp at a given current is greatly influenced by the kind and quantity of the filling gas.

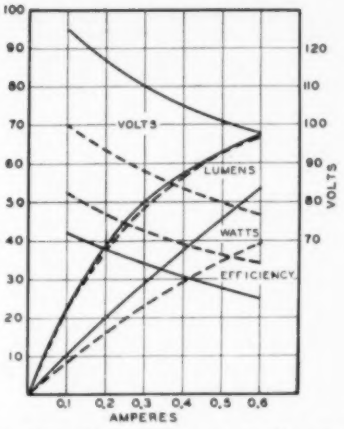


Figure 4. Lamp characteristics as a function of current at 45°C (solid curves are for Ar, dashed for Kr).

As pointed out previously, in practical lamps, the current, pressure of mercury, and gas fill[illegible] are not independent variables. As the current is increased the wattage increases and as a result

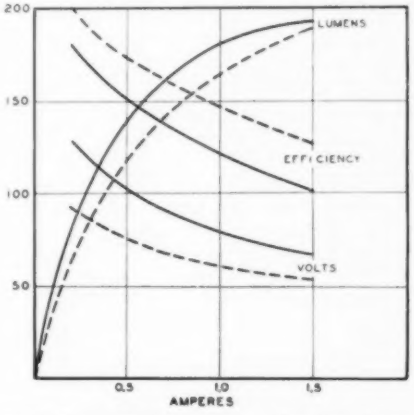


Figure 5. Lamp characteristics as a function of current (solid curves are for Ar, dashed for Kr).

the pressure of mercury increases. Also, it is seen from the curves of Fig. 4, as the molecular weight of the rare gas filling is reduced, the voltage of a lamp of given geometry and operating at a given current increases thereby increasing the wattage and bulb wall temperature and consequently the pressure of mercury.

Krypton in 48-inch T12 Fluorescent Lamps

The electrical and luminous characteristics of 48-inch T12 fluorescent lamps operating in a steady state are shown graphically in Figs. 5 and 6. The solid lines in each are the average values for six lamps containing Ar at 3.5 mm pressure and the dashed lines for those containing Kr at 2 mm pressure. In Fig. 5 the lumens, lumens per watt, and the lamp volts, as indicated, are plotted as a function of lamp current, while in Fig. 6, the lumens, lumens per watt, and ΔT, the increase in bulb wall temperature above ambient in still air at 28°C, are plotted as a function of lamp watts.

In making a comparison of lamps with different filling gases, there are several logical bases on which such comparison can be made. The comparison can be made at the same current, the same light output, the same efficiency, the same watts, or by the operation of the lamps on a given auxiliary. From Fig. 5 it is observed that for lamps operating at the same current, the Ar-filled lamp gives greater lumens than the Kr-filled lamp at all currents up to 1.5 amps, at which value the light outputs are about equal. However, the voltage of the lamp with Kr is considerably lower than that for the one with Ar and consequently the efficiency is higher. If the comparison is made for lamps of the same dimensions and radiating the same lumens, that is, the same brightness, the curves show that the Kr lamp (strictly speaking, one should describe this lamp as a fluorescent lamp containing mercury and Kr, but for conciseness, this is contracted to Kr lamp in the rest of this paper) must operate at a higher current than the Ar lamp. For example, the present Ar-filled 40-watt lamp operates at 0.42 amp. From the curves it is seen that the Kr lamp must operate at 0.6 amp to give the same lumens as the Ar lamp at 0.42 amp, and the efficiency at these currents is about six per cent higher with Kr. This is less gain for Kr than when operated at the same current because, in order to obtain lumens to equal that for Ar, the Kr lamp has to operate at a higher current and on account of the non-linear relation between current and lumens, as shown in Fig. 4, the efficiency is lower at the higher current. At higher brightnesses the advantage is still greater for Kr. If one compares the lamps at the same efficiency, one observes from the curves of Fig. 5 that more light can be obtained for Kr. If the Kr lamp is operated at the efficiency of the Ar lamp at 0.42 amp, the curves show that about five per cent more light is obtained by the use of Kr.

A comparison of lamps at the same wattage is best seen from the curves of Fig. 6 which show that Kr-filled lamps have an advantage over Ar-filled lamps at wattages above 25 watts in both lumens and lumens per watt, while below this wattage there is a slight advantage for Ar. However, at 40 watts, which is the present normal rating of this lamp, the advantage for Kr in lamps of these physical dimensions is slight, amounting to only about three per cent. The advantage of using Kr becomes much more decided at the higher loadings. For example, at 75 watts, six per cent more lumens are obtained with Kr. The difference is more striking if one compares lamps of equal brightness, *i.e.*, the maximum brightness shown in the curves. In this case the Ar lamp requires 25 per cent more watts than the Kr lamp.

An explanation for the advantage of using Kr at higher brightness is seen best from a consideration of the curve designated ΔT, Fig. 6, which shows the increase in bulb wall temperature above the ambient in still air. When operated at the same wattage, the Ar lamp operates at a slightly higher temperature than the Kr lamp. This is a consequence of the Kr lamp operating at a higher current and thereby consuming a larger wattage in the region of the electrodes and hence a lower wattage in the tube proper. The measurements from which the curves of Fig. 6 were drawn were made at an ambient temperature of 28°C and the cross over in lumens occurs at 25 watts or at a $\Delta T = 12°$, which means a bulb temperature of 40°C. The curve of Fig. 1 shows the optimum light output at the same temperature. Since the Ar lamp is running hotter than the Kr, it will radiate more lumens than Kr at temperatures below the optimum and less lumens at temperatures greater than 40°C as indicated in Fig. 6.

If a fluorescent lamp is designed to replace an existing lamp, it is highly desirable that it should be able to operate on the existing ballast. If Kr is used instead of Ar in the present 40-watt fluorescent lamp and the lamp operated on the existing ballast, it is found that, as a result of the lower voltage with Kr, the lamp now consumes only about 32 watts resulting in about 10-15 per cent reduction in light output and a 10 per cent increase in efficiency. In order to operate at the wattage for which the ballast is designed, a Kr lamp should have the same electrical characteris-

ties as the present lamp. To accomplish this the Kr lamp would have to be either increased in length or decreased in diameter.

From the analysis and comparisons given above, it becomes apparent that higher luminous efficiencies are possible by using Kr as a filling gas in fluorescent lamps. However, it is questionable whether it is economically practical to replace Ar by Kr in the existing design of lamps such as, for example, the 40-watt fluorescent lamp, since such a lamp would require a new ballast in order to operate at the same wattage or with the same light output as the Ar lamp and would make the ballasts for the present Ar lamp obsolete unless the user would be willing to accept about 15 per cent reduction in light for a 10 per cent increase in efficiency. Even at 40 watts, Kr shows only a three per cent advantage in efficiency over Ar and as, naturally, Kr is more expensive, it is questionable whether the gain in efficiency would compensate for the increased cost.

As in the design of all electric discharge devices and electric lamps, in order that the lamps will operate under the most advantageous conditions to afford maximum efficiency, etc., the lamps must be designed to conform electrically with the characteristics of the particular vapor or gas filling employed. Naturally this has been done in the present Ar-filled lamps and has involved the control of the geometry of the lamp to obtain the desired bulb temperature at rated wattage and under normal operating conditions to produce the maximum light output shown in Fig. 1.

In order to make a higher efficiency lamp employing krypton it was not possible merely to take a lamp of given physical dimensions and increase the wattage or current rating to obtain such improved efficiency, but it was necessary to correlate the gas-filling pressure with respect to the wall loading and electrical characteristics, thereby generally giving to the lamp dimensions and ratings which differ substantialy from those of Ar-filled lamps.

From the above analysis it is apparent that Kr will be of greatest advantage in lamps designed to operate at a given voltage and those operating at high loadings.

New 85-watt Fluorescent Lamp

The 100-watt fluorescent lamp was designed to produce a lamp which gave about twice the lumens of the 40-watt fluorescent lamp. In order to do this in a reasonably sized bulb, sacrifices in efficiency had to be made. The size used was a T17 bulb, 60 inches long, operating at 1.42 amps, 72 volts, and 100 watts. At this current, the bulb operated at a temperature of 55°C in still air, which is 15°C above the optimum. If Kr is substituted for Ar, the lamp voltage and wattage for a given current are reduced and the lamp operates at 5°C lower temperature. With Kr at 2 mm pressure, it was found that light output equal to that of the 100-watt Ar lamp could be obtained by operating the lamp at 1.5 amps, 55 volts, and 80 watts, resulting in a 25 per cent increase in efficiency. It was also found that the Kr lamp would operate on the standard 100-watt auxiliary at 1.6 amps, 57 volts, and 85 watts.

The choice of an 85-watt rating for the new lamp was dictated primarily by the fact that the lamp consumed that wattage on the existing 100-watt ballasts and at the same time gave the same lumens as the former lamps which operated at 100 watts. As a result of this characteristic the new lamp can be used in existing equipment.

Even if a new ballast design were acceptable, increasing the lamp wattage to 100 would not result in a proportional gain in light output. Further, the enclosure of this higher-current lamp in a fixture could, very probably, result in temperatures which would bring about a reduction in light output greater than the gain provided by the increased wattage.

Summary

An analysis is made of how the light output and electrical characteristics of a fluorescent lamp are influenced by the mercury vapor pressure, the arc current and the kind and quantity of filling gas.

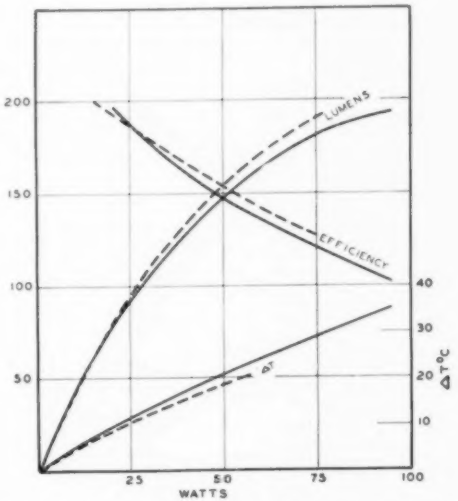


Figure 6. Lamp characteristics as a function of watts (solid curves are for Kr, dashed for Ar).

Comparisons are made between Ar- and Kr-filled lamps. These show that at a given current the voltage drop of a lamp with Kr is much less than for one with Ar. By correlating this characteristic with filling pressure, wall loading, and lamp dimensions, Kr-filled lamps with efficiencies greater than those of Ar-filled lamps can be made. The greatest advantage is obtained in lamps designed to operate at a given voltage and those operating at high loadings. Characteristics of the new 60-inch T17 85-watt krypton-filled lamp are given.

The authors wish to acknowledge the assistance of other members of the Laboratory in obtaining some of the data presented here. We wish especially to thank Mr. L. F. Kramel, Mr. W. F. Hodge, Mr. S. B. Clarke, and Miss J. R. Cooper.

DISCUSSION

GEORGE S. EVANS:[1] This interesting paper serves to illustrate that lamp engineers are quick to apply to lamps beneficial materials and techniques as soon as availability and economic conditions permit. Data[2,3] published as long as eight years ago showed the benefits to be derived from use of krypton as a fill gas in fluorescent lamps, yet only recently has krypton become available in quantities and at a cost which permits its use in fluorescent lamps. The authors have correctly shown that use of krypton gas must be carefully engineered with regard to lamp performance and required auxiliaries; a mere substitution of krypton for argon is not always possible.

In Fig. 3, the authors show the relation of argon pressure and lamp voltage for 48 inch T12 lamps at 0.42 amp. I would like to ask how lamp voltage varies with krypton pressure under the same conditions.

E. W. BEESE:[4] The I.E.S. membership, undoubtedly, wants to know where the use of krypton starting gas will take us and I want to add a few comments to Dr. Found's significant presentation. In the earliest days of fluorescent lighting, we decided to make the 20-watt 24-inch T12 available. Its two-foot length was chosen because that was the longest argon type lamp that would start and operate dependably on 118 volts potential. Had we used krypton, the lamp could have been 33 inches long for comparable operation and had krypton been more plentiful no doubt a lamp that length would have been developed long ago. Now, however, ten years later we have brought out the krypton type 25-watt 33-inch T12 lamp which provides 50 per cent more light output at only a small increase in lamp and fixture cost.

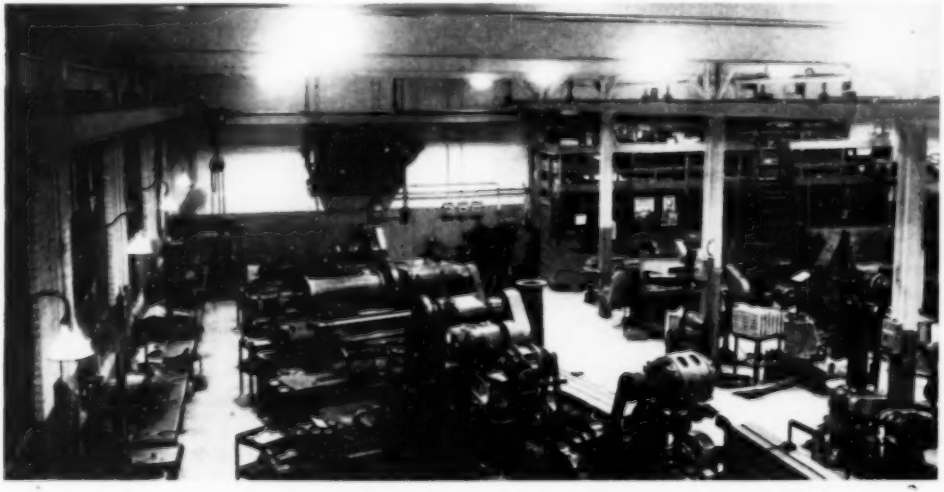
Krypton is now available in quantities not dreamed of in 1937, so it can be and probably will be used extensively. It will generally be provided in new lamps of the preheat type for higher output and lower starting and operating voltages. Instant start types will probably continue to be made with argon because of its lower breakdown voltage where preheated cathodes are not used. Most of the existing preheat types of lamps will continue with argon as they are now because their characteristics are best suited to the use of that type of starting gas.

[1]Westinghouse Electric Corp., Bloomfield, N. J.

[2]Marden and Meister: "Electrical Characteristics of Low Pressure Discharges," Transactions of the Illuminating Engineering Society, Vol. XXXIV, p. 1095 (November 1939).

[3]Marden, Beese and Meister: "Operating Temperature of Vapor Lamps," Journal of the Optical Society of America, Vol. 30, p. 184 (May 1940).

[4]Westinghouse Electric Corp., Bloomfield, N. J.



Combination mercury-incandescent installation in machine shop, Cambridge, Mass. After 3½ years' service, illumination is 45 footcandles. Photo courtesy Boston Edison Company, through Electric Institute of Boston, Inc.

Lighting of a Textile Finished Goods Perch

LIGHTING OBJECTIVE: To provide illumination of quantity, quality and color for easy and accurate performance of visual tasks involved in final examination of finished worsted and woolen textiles.

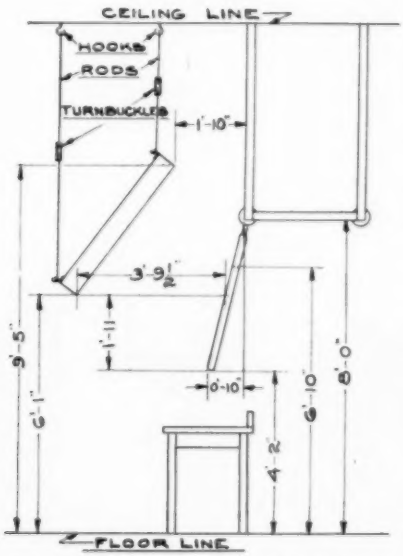


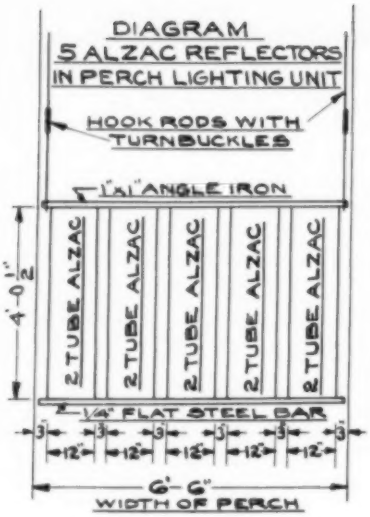
DIAGRAM OF RELATIVE LOCATIONS OF FINISHED GOODS PERCH AND 10-40W FLUORESCENT TUBE LIGHTING UNIT.

Installation at Bachmann Uxbridge Worsted Corporation, Uxbridge, Mass.

General Information: Each examining perch hangs vertically from a framework suspended from the ceiling with the perch-board projecting at a 10-degree angle from the vertical toward the front. The board itself is approximately 6 feet 6 inches wide, 3 feet 9 inches in height with the bottom 4 feet 2 inches above the floor. The eye level of the average examiner is on a line 1 foot 3 inches to 1 foot 9 inches above the bottom edge of the board. The boards are painted a light grey, upper framework and ceiling semi-gloss white, surrounding walls (over 15 inches above floor) light green, and lower (below 15 inches) walls deep apple green.

The cloth (56 to 60 inches in width) to be inspected passes up from a pile folded on a platform in the rear, over a roll at the rear of the supporting frame, horizontally through the frame, over a front top roll and vertically down over the face of the perch-board and then is folded in a pile below the board as it is pulled over, either by hand or automatically. It is examined as it passes over the board. The examiner looks for imperfections of all kinds—wrong colors of yarn, off shades, spots, shadiness of goods and mistakes in pattern.

(Over)



Installation: General room illumination of 40 footcandles is provided by 40-watt, 3500°K fluorescent lamps mounted 10 feet 6 inches above the floor in continuous RLM two-lamp reflectors. The rows are spaced at 11-foot intervals. Supplementary illumination of approximately daylight color and quality, varying from 300 footcandles at the outside edges and bottom of the board to 400 footcandles at the center and top of the board, is provided by units consisting of five twin-lamp polished Alzac reflectors each equipped with 48-inch, 40-watt, 6500°K daylight fluorescent lamps. The frame is mounted in a nearly vertical position and at such an angle and height facing the perch board that a line perpendicular to the face of the reflectors, midway between the ends of the tubes, strikes the board at the eye level of the examiner who stands facing it with the light at his back.

The equipment used was manufactured by The Miller Company, Meriden, Connecticut, specially assembled. The individual units forming the lighting bank are known as Catalog No. FTC - 48.

Lighting data submitted by the Bachmann Uxbridge Worsted Corporation, Uxbridge, Mass., as one solution of a lighting problem and to aid in the design of similar installations.

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The Fallacy of the Louverall Ceiling

By DOMINA EBERLE SPENCER,
WILLIAM H. BUCK, and ARNOLD A. WOLFSON

The inferiority of the louverall ceiling is shown by actual tests on a room. It is found that the louverall lighting gives lower efficiency than a complete luminous ceiling. The principal trouble with the louverall ceiling is, however, that it produces a large amount of reflected glare and is thus entirely unsuited for rooms in which close visual work is to be done.

In accordance with modern engineering practice, quantities are expressed in the mks system. Conversion to English units can be made as follows, if desired:

$$\text{Pharosage (illumination), 1 lumen } m^{-2} = \frac{1}{10.764} \text{ lumen ft}^{-2}$$

$$\text{Helios (brightness), 1 blondel} = \frac{1}{10.764} \text{ ft-lambert}$$

IN HIS search for an ideal lighting system, the illuminating engineer has tried and discarded numerous schemes. Perhaps the latest of these systems is the louverall ceiling. It has aroused considerable interest but is doomed to oblivion where good vision is a prerequisite since it inherently contradicts the principles of best seeing.

The fallacy of the louverall ceiling may be summed up in two words—*reflected glare*. The louverall ceiling has a fine appearance when viewed from the doorway. Shadows are satisfactory and light is well distributed over the room. But if one attempts to work in such a room for long periods, he soon finds that visual conditions are far from ideal. Figs. 1 and 2 show the reason.

The louverall ceiling is the logical outcome of the prevalent but mistaken idea that visual comfort can be obtained only by keeping the surroundings dark and concentrating the light on the work. In accordance with this idea, fluorescent luminaires were provided with louvers and as a final step these louvers were extended to cover the ceiling. Such a scheme does eliminate some of the direct glare but leaves the reflected glare just as it was with bare lamps. And it is reflected glare that is so troublesome to the worker. A room may appear delightful to the lighting expert who glances in through the door but it may be anything but comfortable to the person who must work eight hours a day under the lighting.

That this is not a mere figment of the imagination is shown by the records of ophthalmologists who have encountered thousands of cases of eye complaints concerning fluorescent lighting. Some have even blamed the ultraviolet output of the lamps.[1] The fact seems to be, however, that the trouble is not caused by ultraviolet nor is it eliminated by louvering; it is caused by specular reflec-

DR. SPENCER, MR. BUCK AND MR. WOLFSON are at Brown University, Providence, R. I.

Figure 1. The principal objection to the louverall ceiling is reflected glare. This horrible example happens to have been made with incandescent lamps, but similar effects are obtained with fluorescent lamps.

tion of the lamps in the work and other objects which are in the normal field of view of the worker.

In order to illustrate the relative advantages of the louverall ceiling and the luminous ceiling, an experimental comparison was made.* A small office was provided with a subceiling of cross bars which would accept either luminous panels or louver sections. Thus a change could be made from the louverall ceiling to the luminous ceiling with all other factors kept constant, and the two systems could thereby be compared. The paper describes the results.

Experimental Procedure

In accordance with the idea of producing visual conditions that were as nearly ideal as possible, the walls of the office were repainted with a matte white paint. The furniture and woodwork were repainted in light gray and the floor was covered with asphalt tiles of high reflectance. The approximate Munsell specifications are given in Table I. The ceiling was painted glossy** white and on it were mounted fifteen 40-watt 3500° white fluorescent lamps arranged in five rows (Figure 3).

In the ceiling grid could be placed diffusing panels, approximately 24 by 24 inches (Figure 4). A light frame of plywood supports a sheet of tracing paper and provides an inexpensive translucent plate. The appearance of the complete luminous ceiling is shown in Fig. 5. In order to effect a comparison of lighting under the translu-

*We have compared, of course, only one installation of each kind but obviously the conclusions would be the same no matter how many systems were compared. The trouble with the louverall ceiling is caused by the bare fluorescent lamps which have high brightness and therefore cause reflected glare, irrespective of the size, shape or material of which the louvers are made.

**Since the ceiling is never directly viewed with a luminous ceiling and will stay clean easier if glossy, a gloss white is preferable to a matt white on this particular ceiling.

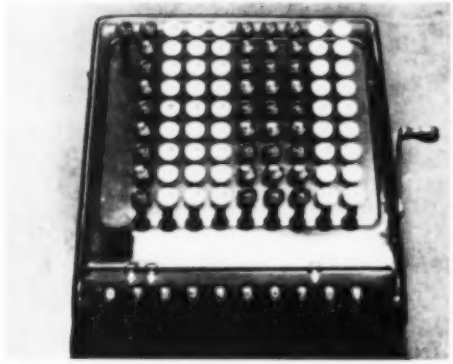


Figure 2. The louvers have no effect on reflected glare. Photograph courtesy W. S. Mowry.

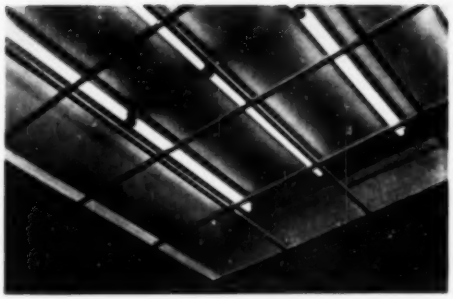


Figure 3. The sub-ceiling is designed to accept either luminous panels or louver sections.

Figure 4. A luminous panel that can be dropped into place in the grid of Figure 3.

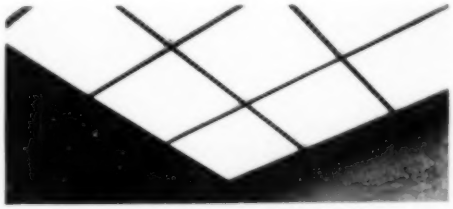


Figure 5. Appearance of the luminous ceiling.

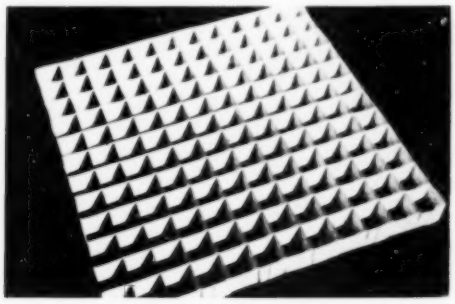


Figure 6. A louver section.

Figure 7. Louvers in place—note the uneven shadows produced along the wall.

Figure 8. Placing the louvers in the sub-ceiling.

cent panels and under a louverall ceiling, egg-crate louvers of white cardboard with two-inch cubical openings were placed in the ceiling grid (Fig. 6). The appearance of the louvered ceiling is shown in Figs. 7 and 8.

Results

Tests were made on the two installations with everything identical except for the interchange of louvers and diffusing panels. Some of the data are given in Table II. These data show that *the louverall ceiling is definitely less efficient than the luminous panels.* The table shows also that the brightness (helios) ratios for the diffusing ceiling are in the neighborhood of 3:1 while with the louverall ceiling a brightness (helios) ratio of 65:1 is obtained. Thus *the luminous ceiling lighting is superior to the louverall ceiling lighting in both quantity and quality.* Table III gives a comparison of experimental values of incident illumination (pharosage) and brightness (helios) with values calculated by the interflection method.[2] The agreement is excellent except for readings taken near the floor, where the large instrument cabinets and other furniture undoubtedly affect the results. The measurement of D_{AV} is lower than the calculated value both because of the effect of the furniture and because the light is so thoroughly diffuse. Before and after photographs of the room are shown in Figs. 9 and 10.

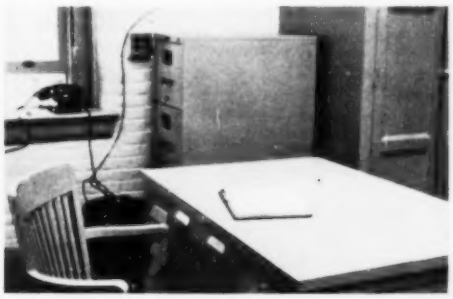
Reflected Glare

Fig. 11 shows the appearance of a book on the desk when the complete luminous ceiling was used. Compare this with the photograph of the same book under the original lighting conditions in the office (Fig. 1). With ceiling lighting there is no possibility of reflected glare since the highest brightness (helios) anywhere in the room is only about three times the brightness (helios) of the work. With the louverall ceiling, on the other hand, with its 65:1 brightness (helios) ratio, there is always potential reflected glare. The appearance of the book on the desk is shown in Fig. 12. Specular reflection is much less marked than with the concentrated incandescent source of Fig. 1. But the reduction in contrast between the printed characters and their background would cause eyestrain.

Conditions under the louverall are also shown in Fig. 13 (a) and (b). Specular reflection in the pa-

Figure 9. Appearance of the office before painting and relighting.

Figure 10. The same office, repainted and with luminous ceiling lighting.



per and in the desk top are evident. Fig. 13 (b) also indicates specular reflection. In this case, the effect of the louverall ceiling with reflectors was reproduced by using black paper over part of the ceiling. The images of the fluorescent lamps are evident.

Table I—Munsell Specification of Colors Used in Refinished Room

Walls	N8
Ceiling	N8
Floor	N6
Woodwork and furniture	N6
Desk top	N6

Figure 11. The luminous ceiling produces an entire absence of reflected glare.

Figure 12. Appearance of same book with louverall ceiling. Note reduction in contrast in some parts of the page.

Table II—The Brightness (Helios) Distribution and Incident Illumination (Pharosage) with Luminous ceiling and with Louvers†

Quantity	Luminous ceiling	Louverall
D_{AV} (incident pharosage)	510 lumen m^{-2}	418 lumen m^{-2}
k_H (coefficient of utilization)	0.257	0.210
H_1 (wall)	325 blondel	234 blondel
H_2 (ceiling)	1409	2466
H_3 (floor)	138	133
H_D (desk)	188	163
H_J (louvers)	.....	785
H_L (lamps)	.....	18,800
H_A* (adaptation helios)	475	287

*Slightly different tasks were used in the two cases.
†Because of the diffusing nature of the louvers the helios was not greatly affected by direction of measurement.

Figure 13. (a) Specular reflections due to louverall ceiling. (b) Images of all five rows of lamps as seen with louverall lighting.

Table II cont'd

Brightness (Helios) Ratios	Luminous ceiling	Louverall
H_A/H_1	1.51	1.23
H_2/H_A	2.96	8.60
H_A/H_3	3.44	2.16
H_A/H_D	2.52	1.76
H_J/H_A	.....	2.74
H_L/H_A	.....	65.5

Table III—Comparison of Calculated and Measured Distribution of Light from Luminous Ceiling

	Calculated	Measured	Ratio
D_{AV}	646	510 lumen m^{-2}	1.26
H_1 (wall)	328	325 blondel	1.01
H_2 (ceiling)	1480	1409	1.05
H_3 (floor)	152	138	1.10

Summary

Tests made on an experimental installation show that the louverall ceiling is less efficient than a complete luminous ceiling. *The outstanding weakness of the louverall ceiling is, however, the presence of reflected glare.* The maximum helios ratio with respect to the adaptation helios of the work is not 3:1 but 65:1 for the louverall ceiling. Thus, images of the lamps are formed in desk tops and other specular surfaces and there is a reduction in contrast between the ink and the paper on which it is printed. Visual fatigue is the result. Thus the louverall ceiling is inherently fallacious as a means of lighting for seeing.

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Practical Schoolroom Brightness Ratios

By R. C. PUTNAM
R. W. WAITE

THE latest concepts of brightness control in schoolrooms have attracted the attention of educators, architects, and illuminating engineers. This interest has been increased by the recommendations in the 1948 publication of the American Standard Practice for School Lighting.

The practicability of these recommendations for brightness ratios and reflectances will be confirmed by experience. The results of a recent investigation are particularly timely as they demonstrate that the recommendations for artificial lighting can be met through the use of materials readily available.

In April 1948, a room in a Mansfield, Ohio, school[1] was remodeled through the installation of new luminaires, new desks with natural wood finish, and through the repainting of all interior surfaces. Between the time of installation and late November when the survey was made, the room had minimum maintenance. The lighting equipment had not been cleaned, the diffusers on the windows had not been dusted, and the paint had not been touched up. One fluorescent lamp had been replaced. The only depreciation noted was three small particles showing as dark spots on the plastic luminaires and several heel marks on the lower wall.

The survey was taken November 26, 1948, from 2:30 to 4:30 in the afternoon. The daylight component was comparatively small during the time that the measurements were taken, as the afternoon was dark and cloudy with some rain. The windows were not provided with shades since the daylight diffusers were designed to reduce sky brightness.

Brightness measurements were taken by use of a Luckiesh-Taylor Brightness Meter. The observer was seated in a rear corner of the room nearest the windows. The brightness readings superimposed on the photograph represent, therefore, the brightness pattern in footlamberts as seen from the particular position on a dark day in late November. On the basis of these readings, the comparison of the brightness ratios to the recommendations for limits of brightness ratios given in the 1948 American Standard Practice for School Lighting (Table I) give values well within the required limits.

The lighting level is well above the required minimum of 30 footcandles, the lowest value recorded (38 footcandles) being on the desk top in the rear corner of the room farthest from the windows.

The reflectances (Table II) obtained by use of a Baumgartner Reflectometer agree closely with the recommendations. The few cases where the reflectances are above the recommended range seem desirable in regard to brightness ratios.

The room is of standard size, 30 x 22 x 12 feet. The luminaires are of the luminous indirect type with plastic reflectors, each unit equipped with two 40-watt 3500° white fluorescent lamps. The 24 units are mounted in four continuous rows.

The qualities of visual comfort which the room possesses are indicated by the various brightness ratios. The natural finish wood desk top with reflectances averaging 42 per cent gives a very low brightness ratio when the visual task involves white paper with average reflectances of 60 per cent to 70 per cent. Visitors comment favorably on the slight variation in brightness between the luminaires and the surfaces adjacent to them.

Figure 1. Room 101, John Simpson Junior High School, Mansfield, Ohio. Figures represent brightness values in footlamberts.

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[1]Room 101, John Simpson Junior High School, Mansfield, Ohio.

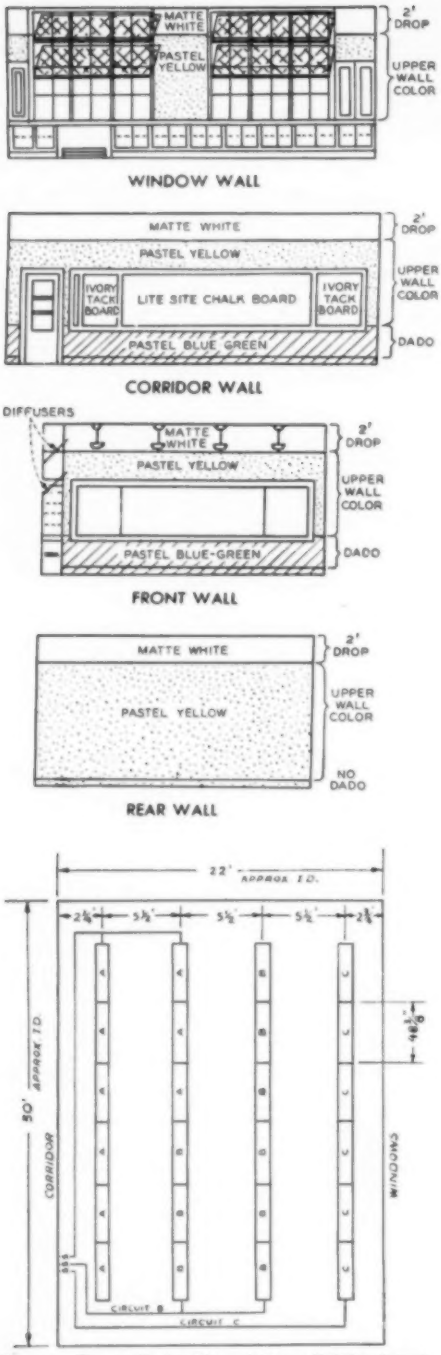

Figure 2. Top, wall elevations; bottom, lighting layout.

Table I—Brightness Ratios*

	Recommended limit**	Observed
a. Between the "central visual field" (the seeing task) and immediately adjacent surfaces, such as between task and desk top, with the task the brighter surface (white paper and desk top).....	1 to 1/3	1 to 1/1.6
b. Between the "central visual field" (task) and the more remote darker surfaces in the "surrounding visual field," such as between task and floor (white paper to floor).....	1 to 1/10	1 to 1/2
c. Between the "central visual field" (task) and the more remote brighter surfaces in the "surrounding visual field," such as between task and ceiling (white paper and ceiling).....	1 to 10	1 to 2.8 (max)
d. Between luminaires or windows and surfaces adjacent to them in the visual fields	20 to 1	3.4 to 1 (max)

*Room 101, John Simpson Junior High School, Mansfield, Ohio.
**American Standard Practice for School Lighting.

Table II—Reflection Factors*

	Recommended limit**	Observed
a. Ceiling	80 to 85%	Above 85%***
b. Walls	50 to 70%	62 to 70%
c. Trim	30 to 40%	48%
d. Tackboards	50 to 60%	67%
e. Chalkboards	15 to 20%	24%****
f. Desk Tops	35 to 50%	42% average
g. Floor	15 to 30%	22%

*Room 101, John Simpson Junior High School, Mansfield, Ohio.
**American Standards Practice for School Lighting.
***The reflectometer was difficult to read accurately in the positions required for ceiling measurements, but all values were above 85%.
****With a light layer of white chalk on boards.

This is confirmed by the brightness readings which give a maximum ratio of 3.4 to 1, where up to 20 to 1 is allowable. Even the floor is sufficiently bright to fall within the 1 to 1/10 limit, although much of the light that would otherwise fall on the floor is blocked by desks and chairs.

Other brightness ratio recommendations have been given by the National Council on Schoolhouse Construction in their "Guide for Planning School Plants (Tentative)," published in 1946. The room used in this study also fulfills their standards for artificial lighting with the exception of the floor which has a lower reflection factor than they require.

It is unfortunate that the measurement of brightness values requires experience in visual photometry and a comparatively expensive brightness meter, as this limits such investigations to those who have both the instrument and the special skill. As the results of these investigations are published and the brightness ratios computed, our knowledge of what brightness ratios are practical and advisable will be broadened.

The agreement of the brightness conditions in this room with the concepts of brightness control as expressed by the published standards is very satisfactory. It is especially encouraging that the result was obtained with materials and equipment that are commercially available.

Designing Portable Lamps for Lighting Effectiveness—Part II

By EUGENE W. COMMERY

This is the second and final installment of Mr. Commery's paper on this subject, the first part of which was published in the February, 1949 issue of ILLUMINATING ENGINEERING. *Part I of "Designing Portable Lamps for Lighting Effectiveness" covered the importance of lamp placement, both in the home and for test measurements; the effect on performance of lamp bulb position; the design of opaque and diffuse reflectors; specular reflection from magazines; equipment for analyzing illumination performance; the design of desk lamps, etc. The entire paper was presented before the National Technical Conference of the Illuminating Engineering Society, held at Boston, Mass., September 20-24, 1948.*—EDITOR.

THE Society's recommendations[2] suggest that there are at least three positions in a room at which one may view a portable lamp in use that are important in assuring overall visual comfort. As we study the uses of portables more closely, we find certain general conditions that should be considered, and after that, special conditions must be added due to certain lamps that are needed for more specialized uses such as studying and makeup at mirrors.

First, the simple concept for appraising general purpose lamps is illustrated in Fig. 16. The light source is shown as a sphere for diagrammatic simplicity. A surrounding shade and the source may occupy any position up or down the vertical line upon which it is drawn. If it is one of the typical 100-200-300-watt three-light floor lamps, the top edge of the shade would be anywhere from 58 to 62 inches above the floor. If it is a 21-inch table lamp on a 25-inch table, the shade top would be at 46 inches. Actually, any type of symmetrical shade or bowl may be considered, from a flat, shallow, closed-top type to a luminous bowl indirect floor torchere. In the event a floor or desk lamp using a tubular light source is to be appraised, the axis of the tube would be placed on the same vertical line. Its height would be in accordance with its designed application and it would face out to the three eye positions, *A*, *B*, and *C*. These eye positions, which we are now calling visual comfort points, were selected for good practical reasons. Others could have been selected. We should consider these particular positions as being quite realistic since they are neither too demanding of the portable lamp's performance nor are they too lax.

The *A* position is used to effect some control over the glaring effects that one experiences when standing near and looking down into a lamp. The nearer the lamp this position is located, the more difficult the shielding of the bulb or tube becomes. Shield-

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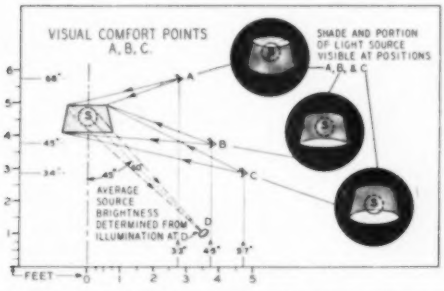


Figure 16. Illustrating three visual-comfort point positions and parts of a typical given standard light source that may be seen at each.

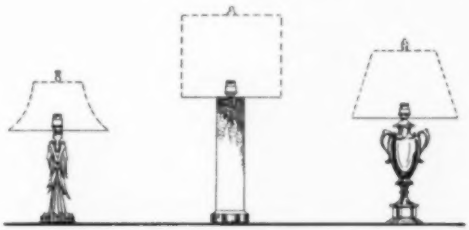


Figure 17. The strict adherence to the rule of placing the bottom of the socket even with the shade bottom seriously interferes with the lighting performance of many lamps.

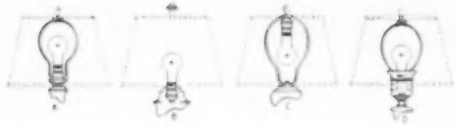


Figure 18. The conventional harp construction (A) places the lamp bulb too high in the shade. The socket sunk in the base (B), the base-up harp (C), or the socket cover harp (D) all offer practical means to better lighting performance.

ing difficulties also increase as we select higher positions for this point. If we select a point too near the lamp and try to protect the very tallest people, the restriction on design will be so great that we cannot provide adequate upward light except in a narrow beam or by making most lamps too high. Here is a point where style trends must be considered. Narrow-beam ceiling distributions are undesirable since they can produce high-brightness ceiling areas that in themselves create real visual discomfort.

Position *A* represents a standing eye height that includes all people except the tallest ten per cent. The distance away from the shaft of the lamp is a reasonable choice. The brightest areas of inside-frosted lamp bulbs should not be visible from this point. From examinations of considerable numbers of experimental shade assemblies, a controlling value of light may be selected for a given design. This method may not always supply values that are tenable for designs that depart radically from the original in brightness pattern. They merely act as a guide and afford a good control for programs using performance specifications built around specific basic design models.

TABLE IV—Direct-Viewing Visual-Comfort Control Value*

Portable Lamp Type	Limiting Measurement—Footcandles Visual Comfort Points A	B	C	D	Light Source Projected Area** at 45° (sq. in.)
Large floor (A) 100/300 w.	8	6	3.5	10	45
Large floor + 32 w. circline	10	6	6	15	45
Swing-arm floor (B) 50/150 w.	6	3.5	3.5	5.5	30
Swing-arm (B) + 32 w. circline	8	6	5	10	30
Bridge 50/150 w.	6	3.5	3.5	5.5	30
Table medium (C) 50/150 w.	6	5	3.5	4.5	25
Wall (B) 50/150 w.	6	3.5	3.5	5.5	30
Table, large (B) 50/150 w.	6	5	3.5	5.5	30
Table, large (B) + 32 w. circline	8	6	5	10	30

*Now included in Certified Lamp Makers specifications.

**Area required for incandescent filament source only. No added diffuser required for fluorescent lamps in models combining incandescent filament and fluorescent. Three different shapes and sizes of diffusers used, i.e., *A* is largest, *B* next in size, *C* is smallest. Light source brightness limit averages 5.5 cp/in.^{2} for *A* diffuser and 4.5 cp/in.^{2} for *B* and *C* diffusers. Shade brightness average limit approximately 200 footlamberts.

Visual comfort eye position *B* is intended to appraise the brightness of the shade as seen from a seated eye position. It may also take into view some of the inner reflecting surface near the bottom of the shade. Through a proper selection of a control value the light source must be shielded down to this point. All but the shortest ten per cent of women seated on a 16-inch chair and facing the lamp were considered in selecting the point.

Point *C* not only views the inner surface of the bottom of the shade but may also include some of the light source. Its position drops down and away from the lamp more than *B*. Its value permits some of the source to be visible if it is moderate in brightness. Point *C* provides some factor of safety for short people in low chairs and for children. Table IV presents the control values for each of the points, *A*, *B* and *C*, now being used in certifying the various C.L.M. lamps. The table also includes the illumination measurement made (*D*) for the determination of the average light source brightness. The minimum projected area of the light source as viewed along this 45-degree line is also included. Reasonable uniformity of light source brightness should be a part of the design. Average brightness is a satisfactory criterion since a selected small area of higher than average brightness does not condemn the quality of the lighting result.

A given lamp to be tested is placed in a black room. The room can be small as the distances from the lamp to the various visual comfort points are short. Any form of illumination meter may be used. The illumination is measured normal to the lamp at each point. When the illumination at the *A* point is measured, the side of the shade is covered with any suitable black material. The *D* point is measured with the lamp shade removed.

The general conditions surrounding the question of direct-viewing visual-comfort need more study, especially as they apply to shade brightness and the inside lower edge of the shade. The opaque shade in itself presents a special problem. The sudden jump in brightness between the outer and inner surfaces of the opaque shade introduces undesirable brightness ratios. If the lamp is for low-wattage decorative use, this brightness ratio is not serious, but placed on a student's desk within a few inches of the eyes, it is very annoying.

The conditions of use of lamps on desks bring the eyes of the user much closer to the shade than is illustrated in Fig. 16. This suggests a more carefully composed set of direct viewing visual com-

fort points for studying at desks. The *A* position can remain the same and for lamps using up to 150 watts or approximately 2500 lumens the control footcandle value at *A* would be 6. The *B* value must be limited to approximately 1.5 footcandles and no part of the inside of the shade or light source should be visible at the *B* point. Since opaque shades are not entirely desirable when placed near walls that are in the immediate field of view when seated at desks, some shade luminosity should be required.[3] The opaque shade creates shadows on adjacent walls between the bright wall patterns formed by light escaping from either the bottom or the top of the shade, or both. In so doing, it means the wall brightness patterns below and above shades are unnecessarily harsh since there is no light fill between the two. When this pattern is directly in front of the eyes of one working at a desk, it may be distinctly unpleasant and undesirable. The translucent low-brightness shade prevents these contrasty wall patterns, and for that reason should be always employed where the lamp is intimately associated with the user. For general work in rooms having numbers of lamps, the opaque shade is not as undesirable if carefully used. The lower edges of their shades should be kept as low as possible and away from walls at least a reasonable distance.

Before leaving this part of the subject, we should turn back to Fig. 4 since the dresser and dressing table lamp are special-purpose lamps. All lamps discussed up to this point have rendered their services primarily through the light escaping from the bottom of the shade or through the top. Nothing has been said about light through the shade except for the direct viewing comfort or discomfort that will arise from shades that are too bright (Fig. 16 and Table IV) or shades that are opaque. Shades have been truly used to conceal and subdue the light source.

The dresser and dressing table lamps differ from all the others. We must get all light possible through the shade since our problem is that of supplying light to the two sides of the face. In supplying 20 or more footcandles on the two vertical planes of the face, it must be done largely by direct light from the source. In other words, we must direct light in the direction of the eyes to accomplish the end.

The problem of design calls for as large a shade as may be used in conjunction with the scale of well designed, widely used dressers and dressing tables. Shades having greater depth than width have the advantage of supplying light up and down the face. The variation in heights of women to be accommodated is also better served. From models of shades made, of average white rayon covers and liners (stretched, not pleated), it was found that shades having a minimum projected area of approximately 50 square inches at an average brightness of 500 footlamberts are required. One interpretation of this shade size has a bottom diameter of 9.5 inches, top diameter of 7 inches and a 7-inch depth. For the taller bases used on dressers, this shade size is not too difficult to style. On the shorter bases for dressing tables the size is near the limit for bulk. The brightness required is over twice that allowed for general-purpose lamps in living rooms and nearly six times that now being suggested for study rooms.

The actual sensation of discomfort from these shades when being used for close examination of the face up in the viewing position at the mirror is not excessive. The actual sustained periods of use are not comparable with those often associated with reading and studying, hence the element of time is much less in producing discomfort. The relatively high brightness of these shades makes it necessary to provide some means of lowering this brightness when not in use for actual facial examination. In

Figure 19. Such factors of design as high lamp-in-the-shade positioning, shades that are too small, and portables that are too low, alone or in combination with each other, account for light on one part of the page and shadow on the rest.

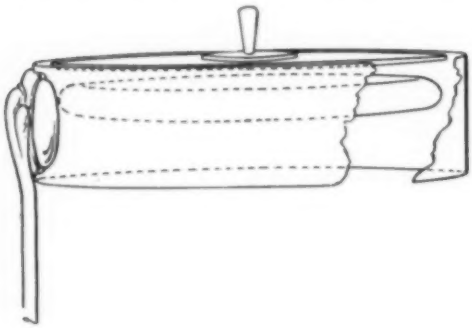
this way they can be made to fall in line with the other lamps in the home. In the sick room, for example, these shades operated at their full brightness-level would prove to be undesirable if they were viewed more than casually. Values of brightness of not more than half value have been found to be quite acceptable. The three-light incandescent filament lamp (30-70-100-watt) operated at 100 watts and 30 watts, respectively, provides the complete unit with the necessary control of illumination and shade brightness.

Visual Comfort From Surroundings

The visual sensations experienced when working with the light from a lamp may not be predicted in advance with certainty even though all of the design requirements now set forth have been met. A given well-designed lamp used alone cannot always create satisfactory ceiling, wall and floor brightnesses since the rooms in which it may be placed vary greatly in dimension, including ceiling height. The reflectance values of the interior may range from black to white. Furthermore, except in specialized cases, a single lamp in a room may not provide comfortable visual surroundings.

In all the foregoing tests and those following, the performance of lamps was always determined in one given room. It has a white ceiling, reflectance 75 per cent; good walls, reflectance 50 per cent; and a light floor, 20 per cent reflectance. It is 12 by 12 feet, and its ceiling is 8 feet 6 inches high. It is a small room, but it is a standard and from it at least comparative studies from one time to another can be made. The illumination results obtained from lamps tested in it are reasonably indicative of the results that may be obtained in good average rooms in the home. Wall brightnesses near and above lamps are typical of those that would result in average rooms. The generally distributed light often measured on a horizontal plane in the center of this test room and the brightnesses on the most removed wall from the portable are somewhat high in comparison with darker rooms or with rooms several times its size. It is not too high in key, however, for comfortable living. It represents an interior that is not unduly difficult to light. Its chief function is that of creating an enclosure that is easily reproduced and from which realistic appraisals of performance can be obtained even though they may not be absolute. The effects we are seeking to evaluate are not sufficiently rigid or absolute in themselves to warrant excessive expenditure for such a test enclosure.

Figure 20. **The shallow larger diameter drum type shade and circular fluorescent lamps provide the designer with sources and forms that may become extremely effective.**



Just how well a single lamp will create ceiling, wall and floor brightness can be observed in the test room. Of special interest is the brightness of the wall opposite the user of the lamp. The floor also takes on interest. These two areas usually frame the surface that we are aiming to light; *i.e.*, they are either adjacent to the reading test plane or they surround it in part or in whole. As we raise the head from concentration to a higher position for diversion or visual relaxation, these areas are always at hand. In every field of lighting, the desirability of minimizing brightness differences between local areas of immediate attention and the surroundings has long been recognized. In the home greater latitudes have always been sought for the values of light and shade because it is home. On the other hand, the physical conditions that provoke visual discomfort between a well-lighted printed page and poorly lighted surroundings in an office or school room will also provoke visual discomfort in a living room. We cannot base our lamp design upon illumination on the test plane alone. The design must also supply general room lighting for overall visual comfort.

There is adequate support in researches dealing with the sensitivity of the visual sense, accuracy of work done and ease of seeing where critical tasks are performed for prolonged periods to establish desirable ratios of brightness between the visual task and its surroundings.[6] To attain good seeing conditions, the brightness of the visual task, for example a book being read, should not be substantially greater than three times the brightness of the surroundings. A book receiving 25 footcandles would have a brightness three-fourths this value expressed in brightness units—footlamberts. The illumination on the book, 25 footcandles, is multiplied by its reflectance of 75 per cent to determine its brightness in footlamberts, exclusive of the specular effect brightness previously discussed. To

meet the brightness-ratio condition, the wall and floor back of the book held in the lap or on top of a table would have to have a brightness of one-third of 19 footlamberts or about 6 footlamberts. Since the wall has a reflectance of 50 per cent, it is going to require about 12 footcandles on the wall. The floor does not reflect nearly as well, so it would require 30 footcandles. This latter value is of course greater than that called for upon the book itself. This analysis merely serves to illustrate some of the unusual difficulties of lighting interiors with one portable lamp in a room in which we may hold a magazine or a book in the lap with the floor as a background. Few lighting problems in other fields of human activity use the floor as a part of the visual background. At this stage of the lighting art and in recognition of the effects sought and long cherished in the home, we may not proceed in our lighting endeavor to such high amounts of generally distributed light to attain full visual comfort from surroundings. Furthermore, the amount of prolonged visual work done in the living rooms of our homes is not the same as in school or industry, so we may properly strive for a lower value of general lighting with respect to the localized lighting from each lamp.

A brightness-ratio between the visual task and the surroundings that is practically attainable and would mark a real step forward in design and lighting practice would aim not to exceed 10 to 1.[7] A single lamp in the test room would have to supply nearly four footcandles to the wall opposite the reader and nine to the floor when it supplied 25 footcandles for reading. In the data that are supplied later showing the performance results of a number of types of lamps, we may learn how well various designs of lamps comply with the 10-to-1 brightness-ratio recommendation. From these data we will see the necessity of using a number of lamps throughout a larger room to achieve this comfort objective.

TABLE V—Illumination Required to Attain Brightness-Ratio, 10 to 1 (Standard Test Room Conditions)

Reading Test Plane	On Wall	On Floor
10 ft-c	1.5 ft-c	3.8 ft-c
20 ft-c	3.0 ft-c	7.5 ft-c
50 ft-c	7.5 ft-c	18.8 ft-c

The more exacting visual conditions associated with study tables and desks call for brightness-difference in the field of view. Through the simple expedient of having the student face the wall, as shown in Fig. 2, only the brightness of the work, of the desk top and of the wall immediately in front needs to be considered. Brightness-ratios not exceeding 3 to 1 for home study may be considered good. The ratios of upward light from well-proportioned table lamps which incorporate 150 watts or a 2600-lumen light source will meet this requirement and the 40 footcandles recommended for home study desks.

Design Combinations

If any one element could be singled out as the greatest deterrent to functional-design progress, it would undoubtedly be the slavish adherence to the socket position so widely used in lamps today. The unwritten law that says that the socket must not show below the bottom line of the shade has reduced the illumination effectiveness in no small way in millions of lamps. Fig. 17 is intended to show the strict adherence to this idea no matter what shape or value the lamp may have. The idea of positioning the lamp bulb base down raises the light source too high in the shade if the socket must be kept above the shade line. Corrective measures have been suggested for years. Sinking the socket in the base introduces some limitations on the design of bases. Arranging the socket in the top of the shade so as to operate the lamp bulb with its base up and the filament position as low as conditions permit does not limit base design. It costs more than the widely-used very low-cost harp construction. If, however, we review the cost of light the user can never get, due to the high positioning of the filament, the extra cost of a harp which

TABLE VI—Illumination on Reading Test Plane
Four table lamps using bare, inside-frosted lamps
(Fig. 1, test positions with lamp on right side)

	Footcandles			
Positions on test plane	A	B	C	D
Upper left corner	12	17	16	8
Top center	21	26	24	14
Upper right corner	35	37	38	24
Right of center (near edge)	37	45	47	26
Lower right corner	35	44	47	25
Bottom center	25	30	30	13
Lower left corner	19	22	22	12
Left of center (near edge)	17	22	20	11
Center	26	32	30	18
Average of 42 points	25	31	31	18

A—Table lamp 25-in. high; shade, white fabric; 16-in. bottom dia.; 13-in. top dia.; 9.5-in. deep; two 60-watt lamps base up; cluster sockets; filament positions, 3½-in. above shade bottom. Shade brightness, 100 footlamberts.

B—Table lamp 25-in. high; shade, white fabric, 16-in. bottom dia.; 13-in. top dia.; 9.5-in. deep; one 100-watt lamp base up; filament position, 3-in. above shade bottom. Shade brightness, 100 footlamberts.

C—Table lamp same as B except 100-watt lamp is at lowest possible position. Filament, 2⅝-in. above shade bottom.

D—Table lamp same as B except 100-watt lamp is up in position where bottom of socket is even with shade bottom (A in Fig. 18). Filament 5⅝-in. above shade bottom. Measurements on horizontal plane even with and out from base center follow: 12-in.—50 ft-c., 18-in.—27 ft-c., 24-in.—17 ft-c., 30-in.—11 ft-c., 36-in.—8 ft-c.

would hold the bulb base up is easily justified. The total lack of performance standards for the tremendous volume of lamps using the conventional harp construction allows this unnecessary waste of light. Fig. 19 illustrates a lighting effect too often associated with ordinary harp construction. Fig. 18 presents the various constructions used to hold the shade and position the lamp bulb. Designed socket covers, such as *D* in this illustration, lower the socket substantially. It should be given serious consideration by designers because it is simple, straightforward, and often has high styling effectiveness. Skillfully applied, it can reduce much of the light now being wasted and can do away with the condition of poor lighting distribution across many pages.

The actual effects of different lamp and socket positions upon the illumination delivered to the 14-inch wide and 12-inch high test plane are presented in Table VI. Four different lamp bulb positions were tested when using the same shade and lamp combination. Lamps *B* and *C* provide nearly the same values throughout, and in doing so indicate that after the light source center reached a point three inches above the shade bottom, little was gained by lowering the lamp farther. Lamp *D* shows the characteristic poor performance at all points of the typical lamp design with the socket placed even with the bottom of the shade, Figs. 17, 18A and 19. The test plane is divided into forty-two squares 2 x 2 inches, and brightness readings are made in the center of each. The illumination values shown are based on these brightness values. This table and those following do not report all of the forty-two measurements. Instead the reader can visualize the condition reported by merely referring to those squares on the test plate that are simply described.

Figure 21. Various combinations of incandescent and fluorescent lamps are suggested for future design and development.

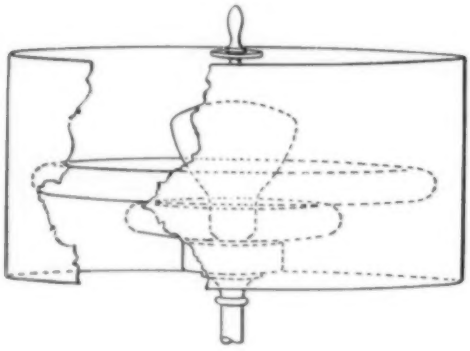


TABLE VII—Illumination on Reading Test Plane
Three table lamps using small open reflector bowls
(Fig. 1, test positions with lamp on right side)

Positions on test plane	Footcandles A	B	C
Upper left corner	4	6	8
Top center	5	10	12
Upper right corner	8	16	18
Right of center (near edge)	13	25	24
Lower right corner	20	26	21
Bottom center	12	17	15
Lower left corner	8	11	11
Left of center (near edge)	5	9	10
Center	9	15	15
Average of 42 positions	10	15	15

A—Table lamp 23½-in. high; shade, white rayon, 16-in. bottom dia., 8-in. top dia., 9⅞-in. deep. 100-watt lamp in 6-in. white glass diffusing bowl. Top edge of bowl 23-in. above lamp bottom.

B—Table lamp 23½-in. high; shade, white rayon, 16-in. bottom dia., 8-in. top dia., 9⅞-in. deep. 100-watt lamp in 6-in. white glass diffusing bowl. Top edge of bowl 20-in. above lamp bottom.

C—Table lamp 27-in. high; shade, white rayon, 16-in. bottom dia., 8-in. top dia., 9⅞-in. deep. 100-watt lamp in 6-in. white glass diffusing bowl. Top edge of bowl 23-in. above lamp bottom.

The 42-point average in this and other tables is obtained from measurements made in the center of each of the 42 two-inch squares into which the test plane is divided.

The first measured appraisals of the performance of floor and table lamps were made on a plane 30 inches above the floor. This was convenient since it closely approximates desk heights. From the measurements so made it was nearly impossible to derive the values that would obtain when a lamp was used in other ways than at a desk. The present methods in use and those now being recommended are closely related to the functional uses of the various lamp types, Figs. 1, 2, 3 and 4. The illumination values supplied on a 30-inch high work plane for lamp *D* may be noted near the bottom of Table VI. It is difficult to relate them to the value for lamp *D* as listed in the table.

Following the more general use of diffusing bowls and reflectors, designers seem to feel that all lamps must have some form of inner diffusing device. The commonest error of design is that of placing the diffusing bowl too high in the shade. This is of course the error of poor design summarized in Table VI. Adding the diffusing bowl does help to smooth out the illumination irregularities. The cut-off, such as we may so often note going across the page one place or another, is blurred and therefore becomes less offensive. Still there are more advantages to be gained beyond that of blurring cut-off lines.

Lamp *A* in Table VII is about as small as a reasonably effective lamp can be. The small diffuser in it is too high in the shade. Note the low value of the whole top of the test plane as well as many of the remaining points. Lowering the bowl 3½ inches

TABLE VIII—Illumination on Reading Test Plane
Large three-light floor lamp
(Floor lamp test positions, Fig. 1, lamp on right side)

Positions on test plane	Footcandles				
	A	A-c	B	B-c	C
Upper left corner	28	29	26	28	30
Top center	33	35	27	31	39
Upper right corner	36	40	30	33	42
Right or center (near edge)	41	43	32	39	48
Lower right corner	38	46	31	36	47
Bottom center	37	44	28	36	43
Lower left corner	30	34	25	29	35
Left of center (near edge)	31	32	26	29	36
Center	35	39	30	34	42
Average of 42 points	35	38	28	33	40

A—Large floor lamp 61-in. high; shade, 18½ in. bottom dia., 14½-in. top diameter, 10½ in. deep, white rayon inside, light natural shantung outside; lamp bulb, 100-200-300 watts. High-transmission diffusing bowl, 10-in. dia. blown glass. Indirect illumination 28% of total. Eleven footcandles on horizontal plane in room center. Second specimen of similar glass delivered 28 footcandles average.

B—Same floor lamp as *A*. Pressed glass waffle bowl, see Fig. 5. Indirect illumination 60% of total. Fifteen footcandles on horizontal plane at room center. Second specimen of similar glass delivered 16 footcandles average.

C—Same floor lamp as *A*. Blown glass bowl, 9⅝ in diameter, very light density glass.

A-c and B-c are lamps *A* and *B*, respectively, to which medium density glass covers having an opening of 4 inches in the center have been added, the intent being to decrease upward light and increase downward light.

(lamp *B*) provides very substantial improvement. If the bowl is to be left in the top of the shade, the overall height of the lamp must be increased to as much as 27 inches if it is to compare favorably with the 23-inch lamp with a bowl placed low in the shade. Comparisons of lamps *B* and *C* illustrate this point.

The density of glass supplied for diffusing bowls has long concerned those intimately associated with the wide range of results that are found between individual lamps that are identical except for the diffusing glass. Table VIII was developed around a series of tests made with a well constructed and properly designed three-light floor lamp to show the effects of diffusing glass that may now be found in homes. Some of it is original and some has been bought to replace broken glass.

The original, or at least early, models of lamps made according to the now discontinued I.E.S. specifications used blown glass, and the resulting illumination afforded very great satisfaction. From these present tests they appear to have supplied an average of 35 footcandles—lamp *A* in Table VIII. Other specimens went as low as 30 footcandles. After a number of years had elapsed, the most frequently supplied glass, such as lamp *B* contained, had increased in density to such an extent that the test plane illumination fell to 28 footcandles from 35, or a decrease of 20 per cent. Other specimens of this same type of glass show decreases up to 45 per cent. In view of the economies presented in the first part of this paper, it would seem as though the light output of a 100-200-300-watt lamp should supply a minimum of 30 footcandles. The restoration of lighting glassware with a more favorable transmission of light would appear to be extremely desirable. A few observations on the proportions of direct and indirect light from a variety of three-light floor lamps can be helpful in appraising some of the relationship between glass transmission and factors of performance. The values in Table IX are somewhat lower than those in Table VIII due to the size of the room in which the measurements were made.

The expedient of redirecting light that formerly escaped from the top of the bowl through the use of top diffusing disks has been suggested. The effects of adding such a disk may be examined in Table VIII. In the cases of lamp *A* it increased the illumination by eight per cent and lamp *B* by 14 per cent. In view of the losses one may expect through the use of this arrangement, the desirability of using glass diffusers having good transmission is to be preferred. When the disk was added to lamp *B*, the illumination on a horizontal plane in the center of the room was reduced from 15 to 11 footcandles. The light passing upward through the hole in the disk also introduces a brightness pattern on the ceiling that is sharp.

Over a period of years the indirect torchere has enjoyed a position of favor with considerable numbers of people. Today there is a very substantial sale of the luminous bowl types. Their effectiveness in producing illumination is indicated through tests of one lamp placed in three positions; (a) regular floor lamp position, Fig. 1, with the shaft of the lamp 17 inches from the wall, (b) same as (a) except moved along the wall one foot, (c) same as (a) except moved along the wall two feet. Details of the separate illumination values over the test plate are omitted since the deviations from the center test-plane value are only about 15 per cent. Using a 100-200-300 watt lamp in the regular floor lamp position (a) the average test plane illumination was 19 footcandles. At position (b) the value is 16 footcandles and at position (c) it is 12 footcandles. At the same time the illumination on a horizontal plane 30 inches high in the center of the room is nearly 10 footcandles. The brightness on the wall opposite the lamp was 4.5 footlamberts. The 16-inch shallow bowl of medium light ivory glass used on this torchere absorbs a substantial part of the light; hence these values may all be considered minimum. Compare 10 footcandles in the center of the room with the same value from the three-light floor lamp having the good glass diffuser, lamp *A* in Table VIII.

TABLE IX—Relationship of Illumination and Glass Density

	Three Glass Diffusers		
	D	E	F
Avg. footcandles	22	16	29
Avg. direct footcandles	9	5	20
Avg. per cent indirect footcandles	60	70	30

D, *E* and *F* are identical floor lamps 61-in. high, with a white rayon shade, 18½-in. bottom dia., 14-in. top dia., 10-in. deep. Lamp bulb, 100-200-300 watts. The *D* diffusing bowl is machine made with cross-hatch surface pattern; *E* is the densest machine-made bowl; *F* is good example of blown glass representing the original type. *E* glass gives very little better performance than that obtainable from an indirect torchere, to be discussed several paragraphs later.

With a more complete history having been developed for the three-light lamps reported upon in Tables VIII and IX, illumination measurements made on a horizontal plane instead of the newer reading test plane are presented more fully in Table X.

TABLE X—Illumination Performance on a Horizontal Plane (Thirty inches high)

	Distance from vertical axis of lamp				
	1 ft.	1½ ft.	2 ft.	3 ft.	4 ft.
	Footcandles				
Three-light, open bowl Good transmission[1]	82	69.5	53	31	20
Three-light, open bowl Medium transmission[2]	57	52	46	30	22
C.L.M.	151	112	78	29	18

[1]Lamp A in Table VIII. [2]lamp B in Table VIII.
Each lamp is placed with its shaft 17 inches from the wall, each illumination reading made 17 inches from the wall.

TABLE XI—Illumination on Reading Test Plane Certified Lamp Makers' Floor and Table Lamps (Floor and table lamp test positions, Fig. 1, lamp on right side)

	Footcandles						
Positions on test plane	A	B	C	D	E	F	G
Upper left corner	28	48	12	23	16	25	13
Top center	35	58	16	29	20	34	22
Upper right corner	41	68	19	35	24	50	32
Right of center (near edge)	51	76	25	42	30	55	36
Lower right corner	55	86	27	47	31	59	31
Bottom center	48	77	23	39	28	45	25
Lower left corner	37	61	17	33	22	28	17
Left of center (near edge)	34	55	16	29	19	30	17
Center	43	68	21	37	28	43	24
Average of 42 positions	41	67	20	35	24	41	24

A—Floor lamp, 100-200-300 watts; 59-in. high; bell-shaped shade in service one year, white inside, 18-in. bottom dia., 14½-in. top dia., 10-in. deep. The average illumination is increased to 48 footcandles with new white-lined opaque shade. Wall brightness opposite lamp, 2.4 footlamberts. Horizontal-plane footcandles in center of room, 8. Indirect lighting illumination, 7 footcandles on test plane.

B—Floor lamp same as A except model also includes 32-watt circline fluorescent lamp. Opaque shade. Wall brightness opposite lamp, 4.1 footlamberts. Horizontal plane footcandles in center of room, 11. Values for fabric shade approximately 15 per cent less.

C—Floor lamp, swing-arm or junior, 50-100-150 watts; top of reflector 56-in. above floor; white lined rayon shade, 17-in. bottom dia., 15-in. top dia., 11-in. deep; top of shade 57½-in. above floor; model B glass, see right hand of Fig. 5. Indirect illumination on test plane, 3.6 footcandles. Opposite wall brightness, 1.5 footlamberts.
D—Floor lamp swing-arm same as C except model has 32-watt circline fluorescent added. Indirect illumination on test plane, 5.4 footcandles. Opposite wall brightness, 2.8 footlamberts.

E—Bridge lamp, 50-100-150 watts; top of reflector 57-in. high; opaque shade, white lining, 13-in. bottom dia., 10-in. top dia., 8-in. deep. Indirect illumination on test plane, 3 footcandles. Opposite wall brightness, 1.0 footlambert.

F—Large table lamp, 50-100-150 watts, top of reflector 27½-in. high; white crepe silk shade, 16-in. bottom dia., 15-in. top dia., 11-in. deep. The fluorescent lamp alone supplies 22 of the average 41 footcandles provided. Indirect illumination on test plane, 4.6 footcandles. Opposite wall brightness, 2.8 footlamberts.

G—Medium table lamp, 50-100-150 watts; top of reflector 25-in. high; white bell-shaped crepe silk shade, 16-in. bottom dia., 8½-in. top dia., 10-in. deep. Indirect illumination on test plane, 2.3 footcandles. Opposite wall brightness, 1.5 footlamberts.

Tables XI, XII, and XIII supply details of illumination performance from lamps of the most modern design and lamps using the newest of light sources. Comparative studies of a considerable number of types of lamps can be made directly since standard conditions of test were employed throughout. A careful study of these and the preceding tables will surely justify the contention that lamps can be designed to perform, and their performance can be analyzed. Generalities should step aside once the facts are found. There can be no question about the future possibilities of portable lamp performance qualities. The data and analyses offered in this study, it is hoped, will aid in serving all those who design, manufacture, buy, sell, and most important, those who use lamps in their homes for beauty and function.

TABLE XII—Illumination on Reading Test Plane Floor and table lamps equipped with 150-watt, white indirect-lite lamp, R-40 bulb (Test positions, Fig. 1, lamp on right side)

	Footcandles			
Positions on test plane	A	B	C	D
Upper left corner	9	12	11	17
Top center	16	22	19	15
Upper right corner	24	36	35	12
Right of center (near edge)	46	49	56	15
Lower right corner	46	44	54	19
Bottom center	35	34	39	23
Lower left corner	18	23	21	24
Left of center (near edge)	13	18	18	23
Center	23	31	32	19
Average of 42 positions	26	30	32	19

A—Table lamp on 25-in. table; lamp height, 25-in. Translucent paper shade, 16-in. bottom dia., 12¾-in. top dia., 10-in. deep, white lining. Bottom of socket placed even with bottom of shade (conventional position). Opposite wall brightness, 1.3 footlamberts.

B—Table lamp same as *A* except socket is lowered 1⅞-in.

C—Small table lamp on 25-in. table; translucent white paper shade, 14-in. bottom dia., 10-in. top dia., 9-in. deep. Top of lamp 49-in. above floor; socket 1⅝-in. below shade bottom. Indirect illumination on test plane, 3 footcandles. Opposite wall brightness, 1.4 footlamberts.

D—Junior floor lamp, 57-in. to top of opaque shade. Socket 2-in. below shade bottom. Opaque shade, white lining, 16-in. bottom dia., 13-in. top dia., 10-in. deep. Indirect illumination on test plane, 3.2 footcandles. Opposite wall brightness, 1.2 footlamberts.

TABLE XIII—Illumination on Reading Test Plane Floor and table lamps with circline fluorescent tubes (Fig. 1 test positions, lamp on right side)

Position of test plane	Footcandles					
	A	B	C	D	E	F
Upper left corner	19	30	25	37	9	7
Top center	30	46	32	52	13	12
Upper right corner	39	59	42	55	17	23
Right of center (near edge)	42	61	48	58	20	29
Lower right corner	36	56	47	54	18	28
Bottom center	27	39	42	47	17	18
Lower left corner	18	27	32	38	12	10
Left of center (near edge)	20	30	30	43	10	7
Center	32	47	42	50	17	20
Average of 42 positions	29	44	38	49	15	17

A—Large modern table lamp with white fibre glass drum shade 5-in. deep, 18-in. dia., closed top. One 32-watt circline fluorescent tube. Opposite wall brightness 1.1 footlamberts. See Fig. 20.

B—Same as A except lamp has one 32-watt circline and one 22-watt circline lamp in same plane. Bottom edges of tubes 1¾-in. above bottom edge of shade. Opposite wall brightness, 1.9 footlamberts.

C—Lamp B moved back and into floor lamp position.

D—Floor lamp 59-in. high with one 32-watt and one 22-watt circline fluorescent tube surrounding one 150-watt, white indirect-lite lamp. White crepe silk shade, 18-in. bottom dia., 14-in. top dia., and 10-in. deep. Opposite wall brightness, 2.3 footlamberts. Illumination on horizontal plane 30-in. high in center of room, 10 footcandles. See Fig. 21.

E—Bridge lamp 56-in. high with one 22-watt circline fluorescent tube. Bottom edge of tube 2-in. above bottom edge of shade. Low-brightness white paper shade, 13-in. bottom dia., 10-in. top dia., 8-in. deep. Opposite wall brightness, 0.4 footlamberts. Ten footcandles on horizontal plane in center of room.

F—Table lamp 23-in. high with one 22-watt circline fluorescent tube. Bottom edge of tube 2-in. above bottom edge of shade. Biege silk shade with white crepe lining, 16-in. bottom dia., 10-in. top dia., 10-in. deep. Opposite wall brightness, 0.4 footlamberts. Same as *E* on horizontal footcandles.

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6. Luckiesh, Matthew: *Light, Vision and Seeing*, D. Van Nostrand Co., 1944.

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DISCUSSION

HENRY R. FELDMAN: Thanks to Mr. Commery—not for all he has done as Technical Consultant to the Certified Lamp Makers or for his many contributions to the art of lighting, but for being the author of the very important paper just presented.

To those of us who have spent much time living and working with these ideas and suggestions there are many things we know. But they are the things we know because we have talked about them in smaller groups such as the Certified Lamp Makers Advisory Board or at various intimate meetings and discussions. However, here, Mr. Commery has put them down on paper so that these ideas may be understood not by just a few of us, but now any interested person in the home lighting field can understand what is being done, what remains to be done and what can be done in making, selling and using better portable lamps in the home.

In my official capacity I am particularly pleased with Mr. Commery's paper. Here is embodied the thinking, the achievement and the hopes of the Certified Lamp Makers program.

The growing up of the lamp manufacturer is being evidenced by the new Certified Lamps now being produced and sold. The reason for this "higher education" is not because the average manufacturer or designer of portable lamps has become smarter, but because the work done by the Society and its experts in the home lighting field has been brought down (or should I say up) to a level which the average manufacturer and designer can now understand.

One clear example of this progress is shown in Mr. Commery's comment in the chapter Design Combinations where is pointed out what has been perhaps the outstanding evil of portable lamp design, more specifically in regard to table lamps. In this particular phase of the subject, Mr. Commery gives a beautifully lucid picture as well as a most emphatic one of what's wrong with putting sockets where they should be. The Certified Lamp Makers program leads the way in eliminating this deterrent element in functional and design progress.

The Certified Lamp Makers program is in one sense opposite to the previous IES lamp program. The old program started with, and emphasized, a fine study lamp, which we might call the unromantic and unemotional part of the lamp business. The Certified Lamp Makers has thus far neglected this phase in favor of the best seller styles, or the more popular types of lamps used in the home. But we are fully aware of the shortcomings and the Certified Lamp Makers take cognizance of the need for the right study lamp (which we might term a necessity), and the right lamp for reading in bed (which we may call a luxury), and these new types will be added to the Certified Lamp Makers' program as soon as is possible. I take it that these are new proposals being suggested here and I think the Society is in complete agreement with the need for these lamps and I know that Certified Lamp Makers will respond to the challenge as they have with the other types, and will produce better lamps than we have ever seen along these lines.

I believe that outstanding contribution presented here today is represented in Mr. Commery's work and his explanation of tests and testing equipment. This work has made it possible for the manufacturer and designer of portable lamps to work with some reasonably simple ideas and many inexpensive and relatively small equipments that have contributed much in the design and the building of better portable lamps.

This latter contribution by Mr. Commery has helped create a greater understanding of footcandle values, glare reduction by proper diffusion and other basic fundamentals of good light in the mind of manufacturers of portable lamps, and it is my belief that this "basic education" has resulted in the improvement of portable lamp construction and design over the past few years.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Review of the February Council Meeting

Fifteen members of Council, and some twelve visiting Committee Chairmen and guests attended the regular meeting of the Society's Council on February 9 at the Hotel Roosevelt, New York City. The meeting convened at 10 a. m. and extended to a full-day session. A brief review of the more pertinent discussions and actions are reported here. Present at the Council were: Lee E. Tayler, President; G. K. Hardacre and R. W. Staud, Past-Presidents; C. H. Goddard and Walter Sturrock, Vice-Presidents; E. M. Strong, Treasurer; A. H. Manwaring, General Secretary; Carter Lewis, Hoyt P. Steele, and M. N. Waterman, Directors.

Regional Vice-Presidents, present included: G. W. Beals, R. L. Biesele, Jr., Joe B. Browder, Harry Grattan, Jr., Duncan M. Jones and W. F. Little as proxy for Allan E. Parker. Also present were A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Production Editor; and Clayton E. Ellis, Advertising Manager.

The following also attended: R. R. Brady, R. W. Butts, Denny Freeman; R. F. Hartenstein, S. G. Hibben, E. C. Huerkamp, C. C. Keller, W. F. Little, H. H. Magdsick, George E. Shoemaker, J. S. Schuchert and A. F. Wakefield.

LATEST MEMBERSHIP FIGURES

A report of the General Board of Examiners, submitted by Roy C. Kinney, Chairman, presented for election or transfer, 13 Members, 103 Associate and 10 Student Members.

C. C. MUNROE NEW MEMBER EMERITUS

On recommendation of the Board of Examiners, Mr. C. C. Munroe, a distinguished and long-time member of I. E. S., was unanimously elected a Member Emeritus of the Society.

Mr. Munroe was retired last year from the Detroit Edison Company, after 48 years service. He was for a number of years in charge of many of their lighting activities and is greatly respected in the lighting field. Mr. Munroe, as is well known to many members, has been active in I. E. S. continuously for nearly 30 years. He was one of the early members of the Michigan Section, in the formation of which he took an active part. Mr. Munroe's long and active service as an officer, chairman and member of numerous committees has been honored in his election to Member Emeritus.

Other changes in the membership status brings the latest figures to those shown in the following table:

September 30, 1948		February 9,1949
6,516	Total Membership	6,815
21	Members Emeritus	25*
45	Fellows	43
1,406	Members	1,470
4,908	Associate Members	5,091
136	Student Members	186

*Includes 5 Fellows of the Society.

NEW SUSTAINING MEMBERS

George J. Taylor, Chairman, submitted for Council's approval two new Sustaining Members.

Favorable action of Council approved for Sustaining Membership:

Modern Light Company
1512 Pine Street, St. Louis 3, Missouri
Official Representative: Karl L. Rundberg

Unadco Manufacturing Co.,
Division United Advertising Corporation,
190 Whalley Avenue,
New Haven, Connecticut
Official Representative: William R. Harris

SOCIETY BROCHURE PLANNED

In his report to Council for the Committee on Finance, Clarence C. Keller reported on a brochure on I. E. S. for use by the Sustaining Members Committee and others in their contacts with prospective members. Such a booklet is already underway.

Mr. Keller also submitted to Council a recommendation of his committee to increase membership dues. His specific recommendation was referred to a special Task Committee for further study, with a report to be submitted to Council at its April meeting. Action was taken by Council, however, to place before the membership on the next ballot a referendum to discontinue the $1.00 discount now allowed on dues invoices.

Mr. Keller further reported that John E. Mueller has resigned from the Committee on Finance. Action was taken to appoint Marshall Waterman to serve the remainder of this fiscal year on that committee.

TWO NEW CHAPTERS

J. B. Browder, Vice President of the Southern Region, presented petitions from members in the vicinity of Nashville, Tenn., and Charlotte, N. C., for the formation of new I. E. S. Chapters in these cities. He indicated that both petitioning groups meet Constitutional requirements, that provisional officers have been elected, and that the groups show evidence of permanent organizations.

Council approved the establishment of the Tennessee Valley Chapter in Nashville, and the Carolinas Chapter in Charlotte, N. C. Further details of the chartering of these new chapters will be featured in a later issue of I. E.

TECHNICAL DIRECTOR'S REPORT

C. L. Crouch, Technical Director, reported to Council on a number of technical committee reports now nearing completion. Some six to eight technical reports are expected to be completed this year in addition to those already approved. Some of those expected to be presented for approval soon include.

Recommended Practice of Daylighting.
Lighting Performance Recommended for Direct and Semi-direct Luminaires.
Revised Recommended Practice of Industrial Lighting.
Lighting for Machining of Small Metal Parts.
Lighting for Bakeries, Steel Mills, Canning Industry.
Contemporary Lighting Practice for Traditional and Modern Interiors.
Q and Q Report No. 5.
Lighting Performance for Supplementary Illumination.

Mr. Crouch further reported the concensus of the Committee on Nomenclature in regard to their proposal for new terms. After extended discussion of all the implications involved in I. E. S. approval of new terms, a mo-

tion was made and approved to submit the Nomenclature Committee's report on new terms to the International Commission on Illumination, I. E. S. Section and Chapter Chairmen, Technical Committee Chairmen and other interested bodies, in such form that they may readily review the terms as applied, for their opinion before final adoption by the Society.

Mr. Crouch also reported that the Report of the Illumination Performance Committee with majority acceptance of that committee was now respectfully submitted for Council approval. The report included a form "Lighting Performance Engineering Data Sheet," intended as a guide for essential data on equipment.

EARLIER DATES PLANNED FOR LOS ANGELES CONFERENCE

In a budget report on the National Technical Conference at French Lick, R. F. Hartenstein, Conference Chairman, also submitted a proposal that the Los Angeles Conference be held August 21-25 in 1950. He also suggested August 26-September 1, 1951, for the Conference to be held that year in Washington, D. C.

Discussions presented the considerations of such earlier dates permitting vacation trips in conjunction with the Conference travel, and further, allowing the more convenient attendance at the Conference of college personnel, who are normally tied up with registrations in September. Council approved the suggested earlier dates.

Massachusetts Considers Engineering Registration

House Bill No. 2024 introduced to this year's legislature of the Commonwealth of Massachusetts revolves around the mandatory provision of engineering registration. As reported by the Society's Committee on State Licensing of Professional Engineers (I.E., April, 1946), Massachusetts is one of the few states with permissive registration. In general, opposition is based on the inevitable "grandfather" clause and the fact that the permissive law has worked satisfactorily since its adoption in 1941. Four of the five Board Members are in favor of retaining the present law instead of the new one sponsored by the Massachusetts Society of Professional Engineers.

No decision is expected during this session of the legislature. At present the law would include registration only for those engineers whose services are offered directly to the public. This would presumably cover many lighting engineers and some salesmen of lighting equipment.

Unique Fluorescent Highway Lighting in New England

A new method of illuminating bridges and highways, constituting a marked departure from conventional lighting systems and eliminating the need for headlights is being tested by Sylvania engineers in an experimental installation at Salem, Mass. The test is being conducted on a 500-foot section of the Kernwood Bridge, between Salem and Beverly. Preliminary results indicate that excellent visibility is attained when continuous low - brightness fluorescent lamps are used.

The installation consists of a row of eight-foot slimline fluorescent lamps mounted five feet above the road way on a fence rail along one side of the bridge. The use of a continuous line of light overcomes motorists' objections to the "blinking" effect experienced when low-mounted incandescent lamps were tried in an attempt to avoid poles or other vertical obstructions and virtually eliminates uncomfortable glare from the light source itself.

Specular reflectors throw the light across the 32-foot road to illuminate the sidewalk and curbing and sufficient illumination is produced to enable motorists to drive through the area without the use of headlights. A louver is provided on the fixture which shields the lamp from the eyes of the motorist.

With lights like these along our principal highways, according to O. H. Biggs, General Engineering Manager of Sylvania Electric, motorists could drive without headlights and with much greater safety than at present.

"The system," said Mr. Biggs, "takes advantage of the diffuse light emitted by fluorescent lamps and the high level of vertical illumination produced by cross-lighting. It is believed that this vertical illumination makes such a lighting system safer for driving than conventional systems because of direct object brightness. Also, low-mounting heights make possible bridge design without the use of lamp posts which many architects feel detract from the beauty of the structure."

Sylvania's experimental lighting of Kernwood Bridge is being conducted in cooperation with the Essex County commissioners and the Salem Electric Light Company. Further extensive tests are planned for determining lighting effectiveness and its relation to safety.

1948 Index to be Mailed Early April

The subject and personnel index for the 1948 volume of ILLUMINATING ENGINEERING was delayed in its preparation this year, in consideration of the extra work involved in creating and assembling the journal in its new format. It is now nearing completion, however, and will be mailed to the membership as a separate piece—to be received early in April.

The 1948 Index is being printed in the same form and size of the 1948 volume for binding with the 1948 issues where desired.

NEW TYPE HIGHWAY LIGHTING TESTED—A row of eight-foot slimline fluorescent lamps mounted five feet above the roadway on a fence rail along one side of the bridge comprises a new type of highway lighting being tested on the Kernwood Bridge between Salem and Beverly, Mass. The light is thrown across the 32-foot road to illuminate the sidewalk and curbing and produces sufficient illumination to enable motorists to drive through the area without the use of headlights.

LIGHTING CALENDAR

Society Events

March 3-4, 1949—South Pacific Regional Conference, San Francisco, Calif.

March 8, 1949—Meeting of I.E.S. Executive Committee, New York, N. Y.

March 10-11, 1949—Pacific Northwest Regional Conference, Portland, Ore.

April 2, 1949—Meeting of I.E.S. Council, Edgewater Beach Hotel, Chicago, Ill.

April 10-12, 1949—Southwest Regional Conference, Houston Texas

April 28-29, 1949—Canadian Regional Conference, Toronto, Canada

May 12, 1949—Meeting of I.E.S. Executive Committee, Hartford, Conn.

May 12-13, 1949—Northeastern Regional Conference, Hartford, Conn.

May 23-24, 1949—Great Lakes Regional Conference, Rochester, N. Y.

June 6-7, 1949—East Central Regional Conference, Harrisburg, Pa.

June 8, 1949—Meeting of I.E.S. Council, 51 Madison Avenue, New York, N. Y.

June 9, 1949—Local Activities Conference, New York, N. Y.

June 9, 1949—Meeting of Council Executive Committee, New York, N. Y.

July 13, 1949—Meeting of I.E.S. Executive Committee, Philadelphia, Pa.

September 19-23, 1949—National Technical Conference, French Lick Hotel, French Lick, Ind.

Industry Events

March 8-11, 1949 — Essex Electrical League, Fifth Electrical Exposition, Mosque Theatre Bldg., Newark, N. J.

March 9, 1949 — Inter-Society Color Council, 17th Annual Meeting, Hotel Statler, New York, N. Y.

March 10-12, 1949—Optical Society of America, Annual Meeting, Hotel Statler, New York, N. Y.

March 13-18, 1949—National Electrical Manufacturers Ass'n, Winter Convention, Edgewater Beach Hotel, Chicago, Ill.

Week of March 28, 1949—Third International Lighting Exposition and Conference, Hotel Stevens, Chicago, Ill.

March 29-April 1, 1949—19th Annual Safety Convention and Exposition, Hotel Statler, New York, N. Y.

April 2, 1949 — Engineers' Council of Houston, 2nd Annual Symposium, Rice Hotel, Houston, Texas

April 5-7, 1949—Edison Electric Institute, 15th Annual Sales Conference, Edgewater Beach Hotel, Chicago, Ill.

April 12-13, 1949—Canadian Electrical Distributors Association, Annual Meeting and Conference, General Brock Hotel, Niagara Falls, Ontario, Canada

April 19-21, 1949—American Institute of Electrical Engineers, South West District Meeting, Baker Hotel, Dallas, Texas

April 25-28, 1949—Fourth Southern Machinery and Metals Exposition, Municipal Auditorium, Atlanta, Ga.

May 1-6, 1949 — National Electrical Wholesalers Association, 41st Annual Convention, Netherland Plaza Hotel, Cincinnati, Ohio.

May 7, 1949—Eastern Electrical Wholesalers Association, Dinner and Dance, Hotel Astor, New York, N. Y.

May 16-19, 1949—National Fire Protection Association, 53rd Annual Meeting, Fairmont Hotel, San Francisco, Calif.

May 30-June 10, 1949 — Canadian International Trade Fair — Exhibition Grounds, Toronto, Canada

May 31-June 2—Edison Electric Institute, Annual Meeting, Traymore Hotel, Atlantic City, N. J.

June 5-9, 1949—The American Society of Refrigerating Engineers, 36th Spring Meeting—Cruise; St. Lawrence and Saguenay Rivers starting from Montreal

June 20-22, 1949—American Society of Heating & Ventilating Engineers, Semi-Annual Meeting, Minneapolis, Minn.

June 20-24, 1949—American Institute of Electrical Engineers, Summer General Meeting, New Ocean House, Swampscott, Mass.

June 28-30, 1949—Canadian Electrical Association, Annual Convention, Banff Springs Hotel, Alberta, Canada.

July 2-9, 1949—New York State Association of Electrical Contractors & Dealers, Inc., Golden Anniversary Convention, Saranac Inn, N. Y.

August 23-26, 1949—American Institute of Electrical Engineers, Pacific General Meeting, Fairmont Hotel, San Francisco, Calif.

October 11-14, 1949—American Standards Association, Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.

October 17-21, 1949—American Institute of Electrical Engineers, Netherland Plaza Hotel, Cincinnati, Ohio.

October 24-28, 1949—37th National Safety Congress, Chicago, Ill.

November 13-18, 1949—National Electrical Manufacturers Association, Chalfonte-Haddon Hall, Atlantic City, N. J.

60-Cycle Current Underway in Ontario

One of the most important lighting developments ever undertaken in Canada is the change-over from 25-cycle to 60-cycle current in the Niagara Division of the Hydro-Electric Power Commission of Ontario. The Niagara Division, now on 25-cycle, supplies power to the most important commercial and industrial section of Canada, so that such a change-over is news of considerable significance to lighting interests in that area. The lighting industry is expected to benefit particularly with regard to the use of fluorescent units, now extremely limited in their use on 25-cycle current.

The entire program, starting in 1949, is expected to cost some $200,000,000 in raw materials and raw equipment, and to be completed in five to ten years.

New Inside Finish for Lamps Announced

A new inside finish for incandescent lamps, described as "the most outstanding improvement in filament lamps since the introduction of the first successful inside-frosted lamp in 1925," has been announced by General Electric's Lamp Department, Nela Park, Cleveland, Ohio.

The special white finish is the culmination of postwar research in the company's Lamp Development Laboratory at Nela Park. It is a silica substance which acts as a nearly perfect diffuser of light, yet permits high light transmission.

The new finish is being introduced in three new lamp bulbs, a 100-watt lamp, a 100-200-300-watt three-lite lamp and a 150-watt indirect-lite lamp. The new 100-watt lamps resemble 100-watt inside-frosted lamps in size, shape and length of life, the company said. In addition, they have the advantage of providing a diffusion of light, or scattering effect, "markedly superior to the diffusion from regular inside-frosted lamps without diminishing lighting efficiency," the announcement stated. The 150-watt indirect-lite lamp has no counterpart among inside-frosted lamps.

Marvin Pipkin, G-E lamp development scientist, to whom is credited the discovery of the first strong inside-frosted lamp nearly a quarter of a century ago, also played the leading role in the development of this new diffusing finish for incandescent lamps, the announcement said.

Described as "remarkably clean and white in appearance," the new lamps are said by General Electric

to be "especially appreciated" when partially exposed to direct view. All three lamps are considered in the "de-luxe" category at the present time.

While research and development work on the new finish has been completed, the extent of its application to other types of lamps has not been decided, the company said.

High-Intensity Approach Lights Reinstalled at Newark Airport

The high-intensity flashing approach lights which were under test by the Air Transport Association at the Newark Airport earlier this year have been reinstalled with minor improvements for the bad weather landing season. Six months ago they were flown to Arcata, California for testing by the Army and Navy.

The approach lighting system, which includes forty-eight units extending 2800 feet beyond the runway, was designed by Sylvania Electric Products Inc. of Boston, Mass., and installed about a year and one half ago. Twenty-four of the units include high intensity electronic flash tubes which generate approximately a quarter of a billion candlepower of white light, powerful enough to penetrate deep fog and driving snow but pulsed to eliminate pilot blindness.

The system is not intended to replace G. C. A. and I. L. S. instrument landing systems but rather to supplement them by giving pilots a visual guide from the inner marker to the beginning of the runway.

High-Intensity Runway Lighting System First Installed in Far West

McCarran Field, the modern new Clark County Airport near Las Vegas, Nevada, recently became one of the first public airports in the far west to install a high-intensity runway lighting system.

Developed jointly by General Electric and the American Gas Accumulator Company, the lighting system makes the field one of the nation's safest for night landings under even the poorest conditions of visibility, according to G-E engineers.

Built by the county with the assistance of the C. A. A., the airport, named for Nevada Senator Pat McCarran, officially was dedicated December 19.

Designated as a Class V Express Airport, it consists of two 6,500-foot paved runways, one graded runway, 16,100 linear feet of taxiway, 31,100 square yards of loading apron and an administration building with approximately 27,750 square feet of floor space.

The northeast-southwest instrument runway, which is 150 feet wide and 6,500 feet long, is lighted by 72 high-intensity runway marker lights and 12 high-intensity green threshold lights, all complete with individual 200-watt isolating transformers. Each of the lights when used at capacity output is capable of producing in excess of 55,000 candlepower of light.

One hundred elevated medium-intensity lights have been installed along the east-west runway and taxi entrances. Each uses a 40-watt isolating transformer. Other lighting fixtures include a 36-inch rotating beacon, an illuminated wind cone, with hinged support, movable controllable landing direction indicator, and an airport control panel.

A special static type regulator of 20 kilowatt capacity, never before used at an airport was designed to operate the runway lights.

More than 8,000 feet of fibre duct and approximately seven miles of cable were laid underground to carry power to the lights. Duplicate controls, one located in the control tower and the other in the transformer vault, enable operators to control the field lighting from either location.

ABOUT PEOPLE

William C. Hipple has retired from the Westinghouse Lamp Division after 47 years of lamp manufacturing. He is best known for his work as Superintendent of the Trenton Incandescent Lamp Plant for thirty years since its opening in 1917. More recently he has been engaged in the plant expansion program of foreign licensees of the Westinghouse Electric International Company.

Among appointments announced recently by Sylvania Electric Products Inc. was that of **S. B. Williams** as Manager of Public Relations. Mr. Williams was president of the Illuminating Engineering Society (1944-1945) and has been with Sylvania since he resigned as editor of *Electrical World*. A second announcement concerned **H. G. Kronenwetter** who has been placed in charge of advertising production for all company units which include the Lamp and Lighting Fixture Divisions. For basic research in power metallurgy, particularly in the fields associated with tungsten and molybdenum, **Dr. J. R. Dedrick** formerly at the University of Cincinnati and **Dr. B. H. Alexander** formerly at the Carnegie Institute of Technology have joined the Bayside, L. I., laboratory staffs.

Leslie K. Schoenbrod has been elected as President and General Manager of Electro Manufacturing Corporation, Chicago, after an association which covered almost the entire period of that company's interest in fluorescent fixtures. To replace Mr. Schoenbrod as Vice-President, the firm has called upon **William D. Cahill**, formerly Secretary-Treasurer.

Byron G. Jaqua has joined the Scott-Jaqua Company, Inc. of Indianapolis, Indiana, as Vice-President.. Mr. Jaqua is a registered professional engineer in Indiana and a graduate of Purdue University. He is the son of Charles A. Jaqua, President and founder of the Company.

Miss Beth McCrone has become associated with the California Electric Supply Company of San Francisco since her return from a year's work and study at the General Electric Company Lamp Department at Nela Park, Cleveland. Formerly a home lighting consultant for Pacific Gas and Electric Company Miss McCrone made a summer's tour of Europe in 1947 to study lighting developments in Great Britain and on the Continent before going to Nela Park.

R. E. Lagerstrom of the General Electric Company Lamp Department at Oakland, Calif., addressed the Electrical Contractors Association of Honolulu on "Store Lighting" and reviewed latest developments in lamps at a luncheon meeting of the Honolulu Engineers Club during a recent trip to the Hawaiian Islands. He found the dining room illumination of the newly-remodeled Royal Hawaiian Hotel one of the finest dining room installations he had seen. Another interesting new lighting design was encountered in the lanai dining room of the Kona Inn in Hawaii.

LOCAL MEETINGS

DES MOINES

The storms which brought forth the dramatic Operation Haylift registered a minor nuisance in cancelling the Midwinter Conference of the Iowa Section scheduled for Des Moines on Friday, January 28. Only six "outsiders" reached Des Moines, and this group was delayed appreciably by snow, ice, and a railroad wreck. Mr. H. P. Wilson, Secretary-Treasurer, advises that the Conference may be rescheduled for late March.

NEW ORLEANS

The New Orleans Chapter took an active part in the Louisiana Engineering Society's Annual Meeting on January 13th, 14th, and 15th, acting as co-sponsor of the Friday morning session at which Mr. S. B. Williams, of Sylvania Electric Products spoke on "New Social Concepts for the Engineer." Mr. Hutson Colcock, local chairman, presided.

MONTREAL

The Montreal Section has just completed two excellent lighting forums —the first on fluorescent lighting at Quebec on January 17th, reported elsewhere in this issue, and the second on street lighting at Montreal on January 26th. Both extended over the afternoon and evening. Montreal's speakers included Messrs. Eshelby, Thomas LaFlamme, Remine, l'Homme, Leduc, Watters, Cousins, and Tait.

QUEBEC

A program conducted in French and English was sponsored January 17 in Quebec City, Canada, as an extension meeting of the Montreal Section. Thought to be the first I. E. S. bilingual meeting, the program attracted an audience of interested men from lighting and electrical fields in Quebec.

Eight papers comprised the Forum, six of which were presented in French. The meeting was conducted in French also, by George Watters, I. E. S. representative for Quebec City. Mr. Watters and other active I. E. S. members in Quebec province are at present cooperating with the Montreal Section in the formation of an I. E. S. Chapter in Quebec in the near future.

Held at the Palais Montcalm, the program featured:

"Aims and Purposes of the I. E. S.," by Duncan M. Jones, Canadian Regional Vice-President. (In English)

"Applications and Principle of Fluorescence," by F. E. Rinfret, Solex Co. (In French)

"Color Qualities and Lamp Characteristics," by Russ Payson, Canadian General Electric Co. (In French)

"Ballasts and Starters," by J. M. Rousseau, Canadian Marconi Co. (In French)

"Fixture Design, Shielding, Etc.," by Edwin E. Morris, Electrolier Co. (In English)

"Adequate Wiring," by Gilles Sarault, of Tasse, Sarault and Associates. (In French)

"Canadian Electrical Code," by J. Arthur Plante, Chief Electrical Examiner. (In French)

"I. E. S. Membership," by W. J. W. Smith, Shawinigan Water and Power Co. (In French)

THE FIRST I. E. S. MEETING conducted in two languages was held recently in Quebec City, Canada. Some of the men responsible for the successful French-English Fluorescent Lighting Forum are: in photo at left, J. Thomas, Chairman, Montreal Section; J. M. Rousseau, Gilles Sarault, George Watters, Chairman of the Forum. In photo at right, W. J. W. Smith, F. E. Rinfret, E. E. Morris, Russ Payson, Duncan Jones, Canadian Regional Vice-President.

More Lighting Courses Announced

Three more IES-sponsored lighting courses have been announced to swell the already impressive total of nine described in the January and February issues of ILLUMINATING ENGINEERING. One of these will have been completed before this issue is printed —an eight lecture course at McGill University inaugurated by the Montreal section. Attendance at the early lectures indicated a sustained interest by the 74 electrical wholesalers, contractors, architects, consulting engineers and utility personnel who were registered. The series consisted of: (1) Light and Sight, D. F. Davis, Northern Electric Company, (2) Fundamentals of Illumination, A. H. Mendel, Gary Electric Company, (3) Filament and Gaseous Discharge Lamps, R. K. Owen, Canadian Westinghouse Company (4) Fluorescent Lamps, M. Laflamme, Lafrancois and Laflamme, (5) Illumination Design, R. A. Eschelby, Northern Electric Company, (6) Store Applications, H. J. Dean, T. G. Anglin Engineering Limited, (7) School and Office Applications, D. M. Jones, Curtis Lighting of Canada, and (8) Industrial Applications, W. J. Smith, Shawinigan Water and Power Company.

The Capital Section with the active cooperation of the Electric Institute of Washington has prepared its program on Commercial Lighting Design to appeal most directly to the electrical contractor. Special awards of IES Handbooks will be made for the best solutions to a store lighting problem. The lecturers include Norman Barnes of the Potomac Electric Power Company, Stanley Baker of Sylvania, P. R. Holmes and A. S. Turner of General Electric, and Robin Adair of Westinghouse. The classes are meeting Tuesday and Wednesday evenings, the final session being scheduled for March 9th.

Boston's program is also a joint activity of the local electrical association and I. E. S. (the New England Section). All details have not been completed but the opening session of eight successive Tuesdays will be on March 15th. Since this course follows a number of others given during the past few years, it is being scheduled as an "Advanced Course" according to Mr. J. L. Steffenhagen, General Chairman. For each session, one or two speakers will present the subject. These speakers will be assisted by a "panel of experts" during the question period so that the registrants will have a broad analysis of each topic.

NEW MEMBERS

At the meeting of Council held on February 9, 1949, and the Council Executive Committee held February 10, 1949, the following were elected to membership:

BRITISH COLUMBIA CHAPTER

Associate Member: D. J. Orr.

CAPITAL SECTION

Member: Francis Scofield.

CENTRAL NEW YORK CHAPTER

Member: Prof. Casper L. Cottrell.

CHICAGO SECTION

Member: B. H. Leishman.

Associate Members: W. F. Andrews, E. E. Mathisen, W. J. Staples, R. W. Thompson, H. F. Ulbert.

Student Members: A. R. Kaplan, D. R. Phillips, Joe J. Smith.

CLEVELAND SECTION

Member: M. A. Mortensen, Jr.

Associate Members: E. G. Adams, R. G. Barnett, J. H. Burson, C. W. Carlson, B. E. Duffey, Bernard Gurney, R. S. Hale, J. E. Hannan, W. J. Heran, J. W. Hopler, Frederick W. Kelly, W. S. Kolb, H. S. Lampe, Sr., H. J. McCullough, E. W. Michel, S. C. Neumann, C. L. Osborn, R. F. Schoenbeck, Herbert C. Smith, Philip W. Smith.

Student Members: N. W. Lewis, W. R. Stephens, Jr.

CONNECTICUT CHAPTER

Member: Frederick R. Millhouse.

CORNHUSKER CHAPTER

Associate Members: E. L. Bebb, C. B. Binns, H. G. Sewell, D. V. Short.

DOMESTIC NON-SECTION

Members: A. P. Brown, M. Reiter.

Associate Members: L. E. Blevins, L. W. Cherry, Jr., A. J. Daniels, W. D. Ellis, Alex D. Erwin, Jr., Edward J. Fulton, Herbert H. Gray, Jr., Perry M. Green, Jr., Herschel B. Hall, J. R. Harrell, Andrew L. Jones, Jr., Aubrey L. Jordan, Louis A. King, D. L. McClearen, W. E. Nash, H. P. Norman, III, Fred S. Perkerson, R. L. Person, J. W. Shumate, Earl S. Soper, William R. Speck, N. T. Weems, Jr.

FLORIDA CHAPTER

Associate Members: Harry Brunner, Wesley C. Paxson, Wesley H. Wood.

FOREIGN NON-SECTION

Associate Member: G. J. Sykokis.

INLAND EMPIRE CHAPTER

Associate Members: F. J. Biallas, R. L. Croyle, Edward E. Ralph, J. D. Urquhart, Fred L. White, Harry G. White.

MICHIGAN SECTION

Member Emeritus: Charles C. Munroe.

Members: George Wagschal, Harold C. Smith.

Associate Members: William J. Browne, R. W. Chambers, Paul E. Dunlap, Ralph O. Fleming, J. R. Hechinger, I. W. Marquardt, Charles H. Mathews, R. V. Pollock, Leroy P. Robinson, Russell B. Rooney, F. K. Schatte, Robert Schnaufer, George S. Steven, R. G. Watkins.

MILWAUKEE CHAPTER

Associate Member: Karl O. Hartwig.

Student Member: Charles T. Owen.

MOTHER LODE CHAPTER

Member: F. M. Carter.

NEW ENGLAND SECTION

Associate Members: P. E. Pritzker, David B. Stone.

NEW YORK SECTION

Members: Thomas J. Brennan, Robert L. Zahour.

Associate Members: H. Y. Crounse, Phil Goldberg, A. C. Magnotti, W. G. Owen, Henry T. Salzman, David F. Wood.

OHIO VALLEY SECTION

Student Members: Robert E. Jordan, P. Daniel Read, Otto T. Rosenbusch.

PHILADELPHIA SECTION

Associate Member: J. O. Samans.

PITTSBURGH SECTION

Associate Members: E. H. Pechan, Jr., David L. Slone, M. E. Walker.

PUGET SOUND SECTION

Student Member: John C. Berg.

ROCKY MOUNTAIN CHAPTER

Associate Member: Cleo H. Ross.

SOUTHERN CALIFORNIA SECTION

Member: James Floyd Armstrong.

SOUTH TEXAS CHAPTER

Associate Member: Edward C. Ober.

SOUTHWESTERN SECTION

Associate Members: M. F. Baldwin, O. H. Elledge, Alfred C. Hughes, L. V. Mayfield, W. A. Meyer.

TORONTO SECTION

Associate Member: Roger Sprague.

TWIN CITY SECTION

Associate Member: R. J. Gerde.

UTAH CHAPTER

Associate Members: L. S. Evans, Allen B. Rudy, Harold K. Speirs, Carlos W. Stone, Donald C. Thomas.

Chicago Section Continues U. of Ill. Scholarship

The Chicago Section is continuing its Scholarship activities at the University of Illinois, which was started this past year. Two scholarships of $250.00 each were awarded to winning students, one a junior and one a senior in Illumination Option.

This Scholarship Fund is being continued this year by asking each member of the Chicago Section of I.E.S. to contribute $1.00 or more. Contributions have been coming in generously, according to Bernard L. Block, Chairman of the Section's Public Relations and Publicity Committee, insuring the success of the Scholarship Fund again this year.

Books and Pamphlets

A new publication in the series of standard letter symbols for use in technical and scientific writing has just been announced by the American Standards Association. This is the American Standard Letter Symbols for Physics, Z10.6—1948. The standard was developed by a nationally representative committee working under the sponsorship of the American Association for the Advancement of Science, the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers and the Society for the promotion of Engineering Education. Thirty-six national societies, including I. E. S., associations, and governmental departments took part in the work which resulted in agreements on the standard symbols.

Copies of the American Standard Letter Symbols for Physics, Z10.6—1948 can be obtained from the American Standards Association, 70 East 45 Street, New York 17, New York, for $1.00 per copy. Other standards in the series are: Mathematical Symbols, Z10f—1928; Abbreviations for Scientific and Engineering Terms, Z10-1—1941; Letter Symbols for Hydraulics, Z10.2—1942; Letter Symbols for Mechanics of Solid Bodies, Z10.3—1948; Letter Symbols for Heat and Thermo-dynamics including Heat Flow, Z10.4—1943; Letter Symbols for Chemical Engineering, Z10.12—1946; Illuminating Engineering Nomenclature and Photometric Standards, Z7.1—1942; and Letter Symbols for Gear Engineering, B6.5—1943.

A booklet covering recent studies on road "dazzle" carried out by the Road Research Laboratory in Great Britain,

(Continued on page 21A)

SUSTAINING MEMBERS

Acme Elec. Corp., Cuba, N. Y.

Admiral Lamp Mfg. Corp., Chicago, Ill.

Advance Transformer Co., Chicago, Ill.

Alabama Power Co., Birmingham, Ala.

All Bright Elec. Prod. Co., Chicago, Ill.

Amalg. Elec. Corp., Ltd., Toronto, Ont.

American Concrete Corp., Chicago, Ill.

American Fluor. Corp., Chicago, Ill.

American Sterilizer Co., Erie, Pa.

Appleton Elec. Co., Chicago, Ill.

Ark. Pr. & Lt. Co., Pine Bluff, Ark.

Artistic Lamp Mfg. Co., Inc., N. Y., N. Y.

Art Lamp Corp., Chicago, Ill.

The Art Metal Co., Cleveland, Ohio

Bausch & Lomb Optical Co., Rochester, N. Y.

Benjamin Elec. Mfg. Co., Des Plaines, Ill.

Blue Ridge Glass Corp., Kingsport, Tenn.

Bd. of Water and Elec. Light Comm., Lansing, Mich.

Boston Edison Co., Boston, Mass.

Bright Lt. Refloc. Co., Inc., Bridgeport, Conn.

Brockton Edison Co., Brockton, Mass.

Buffalo Niag. Elec. Corp., Buffalo, N. Y.

Ed. F. Caldwell & Co., Inc., N. Y., N. Y.

Calif. Elec. Power Co., Riverside, Calif.

Cal-Lite, Inc., Hawthorne, Calif.

Calpa Prod. Co., Philadelphia, Pa.

Cambridge Elec. Lt. Co., Cambridge, Mass.

Can. General Elec. Co., Toronto, Ont.

Can. Laco Lamps, Ltd., Montreal, Que.

Can. Line Materials, Ltd., Toronto, Ont.

Central Hudson Gas and Elec. Corp., Poughkeepsie, N. Y.

Central Ill. Lt. Co., Peoria, Ill.

Central Ill. Pub. Ser. Co., Springfield, Ill.

Central Maine Pr. Co., Augusta, Maine

Central N. Y. Pr. Corp., Syracuse, N. Y.

Central Pr. & Lt. Co., Corpus Christi, Tex.

Champion Lmp. Works Div. of Cons. Elec. Lamp Co., Lynn, Mass.

Chicago Miniature Lmp. Works, Chicago, Ill.

Cin. Gas & Elec. Co., Cincinnati, Ohio

Circlite Corp., Chicago, Ill.

City of Burbank, Calif. Pub. Ser. Dept., Burbank, Calif.

City of Glendale Pub. Ser. Dept., Glendale, Calif.

City of Riverside Elec. Lt. Dept., Riverside, Calif.

City Ltg. Department, Seattle, Wash.

Colonial Elec. Prod., Inc., Paterson, N. J.

Colonial Premier Co., Chicago, Ill.

Commercial Light Co., Chicago, Ill.

Commonwealth Edison Co., Chicago, Ill.

The Conn. Lt. & Pr. Co., Waterbury, Conn.

Conowingo Power Co., Elkton, Md.

Cons. Ed. Co. of N. Y., Inc., N. Y., N. Y.

Cons. Gas, Elec. Lt. & Pwr. Co. of Baltimore, Baltimore, Md.

Consumers Power Co., Jackson, Mich.

Consumers Public Pwr. Dist., Columbus, Neb.

Corning Glass Works, Corning, N. Y.

Coyne Elec. School, Inc., Chicago, Ill.

Crescent Elec. Sup. Co., Dubuque, Iowa

Crouse-Hinds Co., Syracuse, N. Y.

Crouse Hinds of Can., Ltd., Toronto, Ont.

Curtis Lighting, Inc., Chicago, Ill.

Curtis Ltg. of Can., Ltd., Toronto, Ont.

Cutler Light Mfg. Co., Phila., Pa.

Dallas Pwr. & Lt. Co., Dallas, Tex.

Day-Brite Lighting, Inc., St. Louis, Mo.

The Dayton Pwr. & Lt. Co., Dayton, O.

Dazor Mfg. Corp., St. Louis, Mo.

Dela. Pwr. & Lt. Co., Wilmington, Del.

Dept. of Water & Pwr., City of Los Angeles, Bur. of Pwr. & Lt., Los Angeles, Calif.

Detroit Edison Co., Detroit, Mich.

Detroit Steel Prod. Co., Detroit, Mich.

Dobkin Elec. Sup. Co., Chicago, Ill.

E. I. duPont de Nemours & Co., Inc., Wilmington, Del.

Duquesne Light Co., Pittsburgh, Pa.

Duro Test Corp., North Bergen, N. J.

Eastern Fixture Co., Inc., Boston, Mass.

East Side Metal Spinning & Stamping Corp., New York, N. Y.

Ebasco Services, Inc., New York, N. Y.

Efengee Elec. Sup. Co., Chicago, Ill.

Elec. Info. Pub., Inc., Madison, Wis.

Elec. Service Mfg. Co., Philadelphia, Pa.

Electric Supply Corp., Chicago, Ill.

Elec. Testing Lab., Inc., New York, N. Y.

Electrified Industry, Chicago, Ill.

Electro Mfg. Co., Chicago, Ill.

Electrolier Mfg. Co., Ltd., Montreal, Que.

Ender Mfg. Co., New York, N. Y.

Englewood Elec. Sup. Co., Chicago, Ill.

Famous Fluor. Ltg. Co., Chicago, Ill.

Federal Elec. Co., Inc., Chicago, Ill.

Fitchburg Gas & Elec. Lt. Co., Fitchburg, Mass.

Fluor. Equip. & Mfg. Co., Cleveland, O.

Fluor. Maint. Co., Inc., Los Angeles, Cal.

Fluores-O-Lite Co., Hillside, N. J.

Fostoria Pressed Steel Corp., Fostoria, O.

H. A. Framburg & Co., Chicago, Ill.

The France Mfg. Co., Cleveland, Ohio

The Frankelite Co., Cleveland, Ohio

Franklin Design Service Div. of Safeway Stores, Inc., Oakland, Calif.

The Frink Corp., Long Island City, N. Y.

Gallagher-O'Brien Elec. Co., Inc., Chicago, Ill.

Garden City Plating & Mfg. Co., Chicago, Ill.

Gen. Elec. Co., App. Dept., Lynn, Mass.

Gen. Elec. Co., Lmp. Dpt., Cleveland, O.

Gen. Elec. Sup. Corp., Bridgeport, Conn.

Gen. Ltg. Products Co., Newark, N. J.

Gen. Outdoor Adv. Co., Inc., Chicago, Ill.

Georgia Power Co., Atlanta, Ga.

Gibson Mfg. Co., Atlanta, Ga.

Gill Glass & Fixture Co., Phila., Pa.

Gillinder Bros., Inc., Port Jervis, N. Y.

Gleason-Tiebout Glass Co., Brooklyn.

Globe Ltg. Prod. Co., Inc., Brooklyn, N.Y.

Globe Mfg. Co., Chicago, Ill.

Goodrich Elec. Co., Chicago, Ill.

Grand Rapids Store Equip. Co., Grand Rapids, Mich.

Graybar Elec. Co., Inc., New York, N. Y.

Gulf States Util. Co., Beaumont, Texas

The Edwin F. Guth Co., St. Louis, Mo.

Hartford Elec. Lt. Co., Hartford, Conn.

Hawkins Elec. Co., Chicago, Ill.

A. Ward Hendrickson & Co., Inc., Long Island City 1, N. Y.

Holdenline Co., Cleveland, Ohio

Holophane Co., Inc., New York, N. Y.

Houston Ltg. & Pwr. Co., Houston, Tex.

Hydro-Elec. Pwr. Comm. of Ont., Toronto, Ont.

Hyland Elec. Supply Co., Chicago, Ill.

Illinois Power Co., Decatur, Ill.

Illum. Eng. Co., Hazel Park, Mich.

Iowa-Ill. Gas & Elec. Co., Davenport, Ia.

Iowa Pub. Ser. Co., Waterloo, Iowa

Jeannette Shade & Nov. Co., Jeanette, Pa.

Jefferson Elec. Co., Bellwood, Ill.

Jersey Central Pwr. & Light Co., Asbury Park, N. J.

Joleco Corp., St. Louis, Mo.

Jones Metal Prod. Co., West Lafayette, Ohio

Joslyn Mfg. & Supply Co., Chicago, Ill.

Kahn Mfg. Co., Inc., Milwaukee, Wis.

Kan. City Pwr. & Light Co., Kansas City, Mo.

Kan. Gas & Elec. Co., Wichita, Kans.

The Kawneer Co., Niles, Mich.

The Kayline Co., Cleveland, Ohio

Kelso- Brunett Elec. Co., Chicago, Ill.

Keystone Elec. Mfg. Co., Phila., Pa.

The Kirlin Co., Detroit, Mich.

Kopp Glass, Inc., Swissvale, Pa.

Kubec Elec. Co., Chicago, Ill.

The La Salle Ltg., Inc., Buffalo, N .Y.

Leander Elec. Mfg. Corp., Chicago, Ill.

Leeds & Northrup Co., Philadelphia, Pa.

Leland Elec. Co., Dayton, Ohio

Libbey Owens Ford Glass Co., Plaskon Div., Toledo, Ohio

Lighting & Lamps, New York, N. Y.
Light Control Co., Los Angeles, Calif.
Lighting Inc., Los Angeles, Calif.
Lighting Materials Ltd., Vancouver, B.C.
Lighting Prod. Inc., Highland Park, Ill.
Lightolier Co., New York, N. Y.
Line Material Co., Milwaukee, Wis.
Litecontrol Corp., Watertown, Mass.
The Lloyd Prod. Co., Providence, R. I.
Louisiana Pwr. & Light Co., New Orleans, La.
Lumidor Mfg. Co. Inc., Los Angeles, Cal.
Luminator, Inc., Chicago, Ill.
T. R. Lyda Mfgrs. Rep., Indianapolis.
Lynn Gas & Elec. Co., Lynn, Mass.
Macbeth Corp., New York, N. Y.
Malden Elec. Co., Malden, Mass.
Markel Elec. Prod., Inc., Buffalo,, N. Y.
Markstone Mfg. Co., Chicago, Ill.
La Cie Martineau Elec. Lte., Quebec, Can.
Metalcraft Prod. Co., Philadelphia, Pa.
Metal Window Inst., Cheltenham,, Pa.
Metropolitan Edison Co., Reading, Pa.
Metropolitan Elec. Sup. Co., Chicago, Ill.
The Miller Co., Meriden, Conn.
Mississippi Glass Co., New York, N. Y.
Mississippi Power Co., Gulfport, Miss.
Mississippi Pwr. & Lt. Co., Jackson, Miss.
Mitchell Mfg. Co., Chicago, Ill.
Mobilite Inc., Jersey City, N. J.
Modern Light Co., St. Louis, Mo.
Modern Lt. & Equip. Co., Chicago, Ill.
Montana-Dakota Utilities Co., Minneapolis, Minn.
Municipal Lt. & Pwr. Dept., Pasadena.
Mutual Sunset Lamp Mfg. Co., Inc., New York, N. Y.
The Narragansett Elec. Co., Providence, R. I.
Nat'l. Chem. & Mfg. Co., Luminall Paint Div., Chicago, Ill.
Nat'l. Lighting Products, Chicago, Ill.
Nebraska Power Co., Omaha, Neb.
Nelson-Tombacher Co., Brooklyn, N. Y.
New Bedford Gas & Edison Light Co., New Bedford, Mass.
New Orleans Pub. Ser., Inc., New Orleans, La.
N. Y. Pwr. & Lt. Corp., Albany, N. Y.
Northern Elec. Co., Ltd., Montreal, Que.
Northern Ind. Pub. Ser. Co., Hammond, Ind.
Northern States Pwr. Co., Minneapolis.
Ohio Edison Co., Akron, Ohio
The Ohio Power Co., Canton, Ohio
The Ohio Pub. Ser. Co., Cleveland, Ohio
Okla. Gas & Elec. Co., Okla. City, Okla.
Omaha Pub. Pwr. Dist., Omaha, Neb.
Overbagh & Ayres Mfg. Co., Chicago, Ill.
Pacific Gas & Elec. Co., San Francisco.
Pacific Pwr. & Light Co., Portland, Ore.
Peerless Elec. Ltd., Outremont, Quebec
Wm. Penn. Fluor. Lt. Mfg. Co., Phila, Pa.
Pennsylvania Elec. Co., Johnstown, Pa.
Pennsylvania Power Co., New Castle, Pa.
Pennsylvania Pwr. & Light Co., Allentown, Pa.,
Pennsylvania Wire Glass Co., Phila., Pa.
The Perfeclite Co., Cleveland, Ohio
Philadelphia Elec. Co., Phila., Pa.
Philadelphia Elec. & Mfg. Co., Phila., Pa.
Phoenix Glass Co., Monaca, Pa.
Pierce Elec. Co., Chicago, Ill.
Pittsburgh Plate Glass Co., Pgh., Pa.
Pittsburgh Reflec. Co., Pittsburgh, Pa.
Planet Prod. Inc., Chicago, Ill.
Polaroid Corp., Cambridge, Mass.
Portland Gen. Elec. Co., Portland, Ore.
Potomac Edison Co., Hagerstown, Md.
Pub. Ser. Co. of Colo., Denver, Colo.
Pub. Ser. Co. of Ind., Inc., Indianapolis.
Pub. Ser. Co.. of North. Ill., Chicago, Ill.
Pub. Ser. Co. of Okla., Tulsa, Okla.
Pub Ser. Elec. & Gas Co., Newark, N. J.
Puget Sound Pwr. & Lt. Co., Seattle, Wash.
The Pyle-National Co., Chicago, Ill.
Quadrangle Mfg. Co., Chicago, Ill.
Quebec Hydro-Elec. Comm., Montreal.
Quebec Power Co., Quebec, Can.
Rambusch Dec. Co., New York, N. Y.
Revere Elec. Mfg. Co., Chicago, Ill.
Revere Elec. Supply Co., Chicago, Ill.
Ritter Co., Inc., Rochester, N. Y.
Rochester Gas & Elec. Corp., Rochester, N. Y.
Rockland Lt. & Pwr. Co., Nyack, N. Y.
Rohm and Haas Co., Philadelphia, Pa.
Ruby-Philite Corp., Long Island, N. Y.
Ruby Ltg. Corp. of Calif., Los Angeles.
Rumsey Elec. Co., Phila., Pa.
Safety Car Heating & Ltg. Co., New Haven, Conn.
St. Joseph Ry., Lt., Ht. & Pwr. Co., St. Joseph, Mo.
Sandee Mfg. Co., Chicago, Ill.
Sandel Mfg. Co., Chicago, Ill.
San Diego Gas & Elec. Co., San Diego.
Savannah Elec. & Pwr. Co., Savannah, Ga.
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Schomer Elec. Supply, Aurora, Ill.
The Albert Sechrist Mfg. Co., Denver.
L. J. Segil Co., Chicago, Ill.
Shawinigan Wtr. and Pwr. Co., Montreal, Que.
Sherwin-Williams Co., Cleveland, Ohio
Sight Light Corp., Deep River, Conn.
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A. L. Smith Iron Co., Chelsea, Mass.
S & M Lamp Co., Los Angeles, Calif.
Smoot-Holman Co., Inglewood, Calif.
Sola Electric Co., Chicago, Ill.
Solar Light Mfg. Co., Chicago, Ill.
The Solex Co. Ltd., Montreal, Quebec
So. Calif. Edison Co., Ltd., Los Angeles.
So. Canada Pwr. Co., Ltd., Montreal.
So. Colorado Pwr. Co., Pueblo, Colo.
So. Ind. Gas & Elec. Co., Evansville, Ind.
So. Lighting Mfg. Co., Orlando, Fla.
So. Gas & Elec. Co. Shreveport, La.
So. Pub. Ser. Co., Amarillo, Texas
Sperti Elec. Mfg. Corp., Norwood, Ohio
Spero Elec. Corp., Cleveland, Ohio
Stanley Elec. Mfg. Co., Philadelphia, Pa.
Steber Mfg. Co., Maywood, Ill.
Steiner Elec. Co., Chicago, Ill.
Sterling Reflec. & Mfg. Co., Chicago, Ill.
Sunbeam Lighting Co., Los Angeles, Cal.
Super Elec. Prod. Inc., Jersey City, N. J.
Sun-Ray Fluor. Co., Chicago, Ill.
Sylvania Elec. Prod., Inc., N. Y., N. Y.
Tampa Elec. Co., Tampa, Fla.
Texas Elec. Ser. Co., Fort Worth, Texas
Thompson Elec. Co., Cleveland, Ohio
Toledo Edison Co., Toledo, Ohio
Toronto Hydro-Electric System, Toronto, Ont.
Torstenson Glass Co., Chicago, Ill.
Triangle Industries, Chicago, Ill.
Tru-Lite Ltd., Montreal, Que.
Unadco Mfg. Co., New Haven, Conn.
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Union Elec. Co. of Mo., St. Louis, Mo.
Union Metal Mfg. Co.,, Canton, Ohio
United Illum. Co., New Haven, Conn.
Utah Pwr. & Lt. Co., Salt Lake City, U.
Verd-A-Ray Corp., Toledo, Ohio
Victory Glass Co., Jeanette, Pa.
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John C. Virden, Ltd. Toronto, Ont.
Virginia Elec. & Pwr. Co., Richmond, Va.
Voigt Co., Philadelphia, Pa.
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The Washington Water & Pwr. Co., Spokane, Wash.
The Watson Std. Co., Pittsburgh, Pa.
The Welsbach Corp., Phila., Pa.
Westchester Ltg. Co., Mt. Vernon, N. Y.
Westinghouse Elec. Corp., Cleveland, O.
Westinghouse Elec. Corp., Chicago, Ill.
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West Penn Pwr. Co., Pittsburgh, Pa.
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Wilmot Castle Co., Rochester, N. Y.
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Windsor Utilities Comm., Windsor, Ont.
Wiremold Co., Hartford, Conn.
Wis. Elec. Pwr. Co., Milwaukee, Wis.
Wis. Gas & Elec. Co., Racine, Wis.
Wis. Pwr. & Lt. Co., Madison,, Wis.
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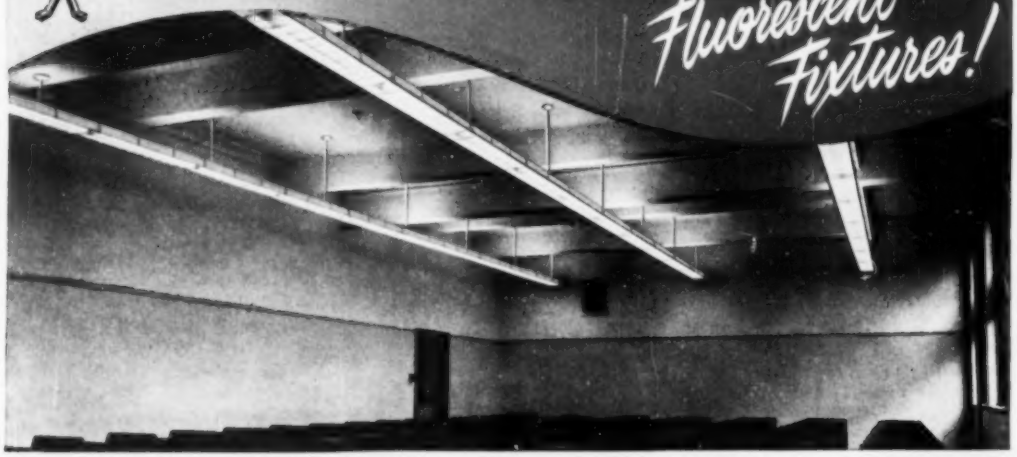
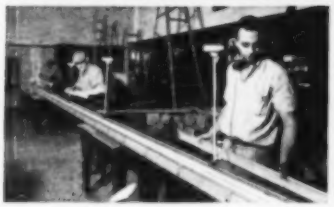
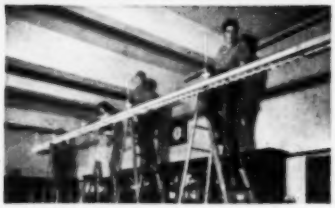
There's no better way to suspend *Fluorescent Fixtures!*

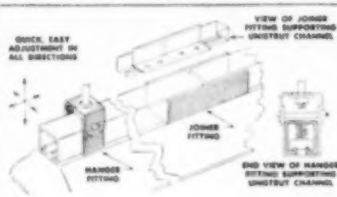






Photographs illustrate the ease and speed with which fixtures are assembled to Unistrut at normal working height, then raised as one unit for suspension. Three minutes after picture at extreme right was taken, installation had been completed.

Installed by Wadeford Electric Co., Chicago, at Oak Park Township High School, Oak Park. Consulting Engineers—Neiler, Rich & Bladen, Chicago. Fixtures by Curtis Lighting Inc., and F. W. Wakefield Brass Co.


QUICK, EASY ADJUSTMENT IN ALL DIRECTIONS
VIEW OF JOINER FITTING SUPPORTING UNISTRUT CHANNEL
JOINER FITTING
HANGER FITTING
END VIEW OF HANGER FITTING SUPPORTING UNISTRUT CHANNEL

New Unistrut Hanger Fitting and Joiner Fitting for quick, easy fixture hanging. Eliminates drilling—allows extreme freedom of adjustment in all directions. A single bolt securely locks clamp to Unistrut.

Send for Pamphlet No. 30
"Unistrut Method of Supporting Fluorescent Lighting Fixtures"

UNISTRUT PRODUCTS COMPANY
1013 W. WASHINGTON BOULEVARD
CHICAGO 7, ILLINOIS

Name _____

Firm Name _____

Street _____

City _____ State _____

4 reasons why "UNISTRUT" ALL-PURPOSE METAL FRAMING

makes fixture hanging easier and results in a better installation

1 FEWER HANGER RODS

Hanger rods may be spaced as far as 15 feet apart, resulting in lower costs and a better appearing installation.

2 PERFECT ALIGNMENT

Unistrut is perfectly rigid and straight—results in true alignment of fixtures. Standard lengths 10 and 20 ft.

3 FASTER, EASIER INSTALLATION

Entire run of fixtures can be quickly assembled to Unistrut *before* raising completed unit to ceiling for suspension.

4 COMPLETELY FLEXIBLE

Hangers may be installed at *any* point along Unistrut continuous slot channel. Allows greater adjustment—easier alignment and leveling of fixtures.

Unistrut has hundreds of other uses—completely adjustable and 100% re-usable!

ALL PURPOSE **UNISTRUT** METAL FRAMING

PRODUCTS COMPANY

Representatives in all Principal Cities

1013 W. WASHINGTON BLVD., CHICAGO 7, ILL.

FREE!

New Booklet to help you sell more (and better)

SCHOOL LIGHTING

16 pages of facts and photos

FREE . . . all the copies you need

Here's a real selling tool . . . an easy-to-understand booklet that points out the need for better school lighting—then *shows what steps can be taken to get a school lighting program started.*

Put this booklet to work for you. Send it to educators, parents, PTA members—all the many hard-to-reach people who must support a school lighting program. *Not fixture advertising!* This is an understandable, objective case history of a planned school lighting program that will help overcome that "What can we do about it" public indifference. Let it help you SELL school lighting . . . the need for it . . . how to get it.

159

IT'S EASY TO SEE WHEN IT'S

DAY-BRITE *Lighting*

Day-Brite fluorescent fixtures are engineered for every seeing task. Distributed nationally by leading electrical suppliers.

Authoritative because it's an actual account of how the citizens of Denver, Colorado, completely relighted their Public School buildings.

***Fact-filled*—step-by-step through the Denver story—answers such questions as:**

- ○ **What's a good way to get started?**
- ○ **Who can help?**
- ○ **What is the best lighting layout?**
- ○ **How does color of paint affect lighting?**
- ○ **What about new wiring?**
- ○ **What about maintenance?**

. . . and many, many others.

. . . as many copies as you need . . . courtesy of Day-Brite! Clip and mail coupon—TODAY!

To: DAY-BRITE LIGHTING
5432 Bulwer Avenue, St. Louis 7, Missouri
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Please send me, free and postage prepaid, _____ copies of your new booklet, "It Happened in Denver's Schools." I understand there's no obligation.

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Address _____

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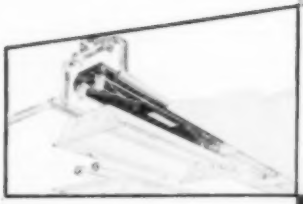
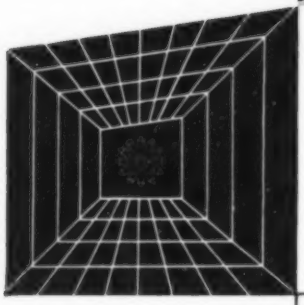
Important reasons for specifying miller fluorescent troffer lighting systems

2



The patented Miller Ceiling Furring Hanger simplifies installation — makes it possible to arrange Troffers to form ceiling patterns as desired — CEILINGS UNLIMITED*. Channels are Bonderized for rust resistance.

Miller Troffers arranged in rectangular ceiling patterns with adjustable spots to high-light displays.



MILLER Troffer installations result in a finished lighting and ceiling job, adequate in illumination, architecturally pleasing, structurally sound and economically produced. Their versatility of application increases the functional value of lighting.

MILLER LIGHTING SERVICE IS ALL-INCLUSIVE covering needs of planned commercial and industrial lighting. Miller field engineers and distributors, conveniently located, are at your call.

THE miller COMPANY

SINCE 1894

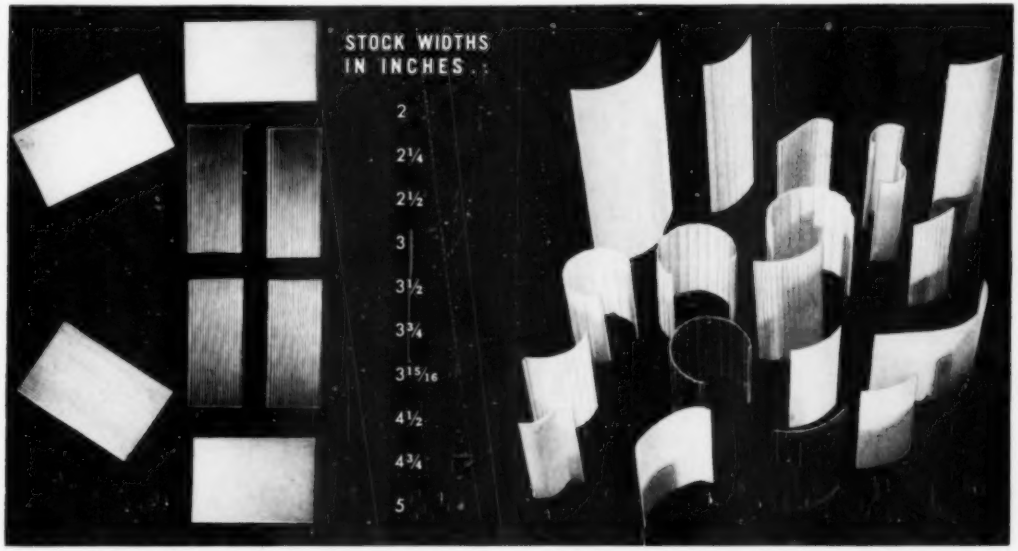
ILLUMINATING DIVISION, MERIDEN, CONNECTICUT

ILLUMINATING DIVISION Fluorescent Incandescent Mercury Lighting Equipment HEATING PRODUCTS DIVISION Domestic Oil Burners and Liquid Fuel Devices ROLLING MILL DIVISION Phosphor Bronze and Brass in Sheets, Strips and Rods

*Reg. Trademark U. S. Pat. Off.

HOW TO *IMPROVE* FLUORESCENT LIGHTING FIXTURES

and Cut Costs, too!



STOCK SIDE PANEL SECTIONS

SANDEE has developed *plastic* side and bottom panels for Fluorescent Lighting Fixtures to a high degree of efficiency! They are now available in clear or translucent materials for quick shipment in both STOCK and CUSTOM sections. Sizes range up to 15 inches in width. All sections supplied cut to length to fit your fixture. They may be used for side or bottom panels in single or *double* widths.

"POLY-LITE" Extruded Panels offer many superior advantages. Electrical Contractors, Electricians and Maintenance men . . *all welcome* Fluorescent Fixtures "POLY-LITE" equipped. They

CUSTOM SIDE PANEL SECTIONS

are 1. easier to install; 2. lighter in weight; 3. *safer* . . much less breakage; 4. easier to clean . . just wipe with a cloth dampened with a detergent.

Other advantages include controlled *uniform* light transmission, very excellent rigidity, remarkable dimensional stability (resistance to distortion), and unsurpassed design possibilities. Take advantage of Sandee's *practical* know-how of materials, designing for extrusion and unique production techniques. Ask our extrusion engineers for suggestions, ideas, samples and cost estimates. There's no obligation.

Sandee Manufacturing Company, 5050 FOSTER AVENUE, CHICAGO 30, ILLINOIS

SALES REPRESENTATIVES IN NINETEEN PRINCIPAL CITIES

"WORLD'S LARGEST CUSTOM EXTRUDERS OF PLASTICS"

"POLY-LITE"®

EXTRUDED POLYSTYRENE SIDE SHIELDS BY SANDEE

they're easier to sell...

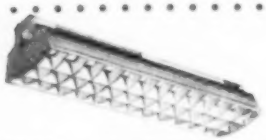
UNDER *Leader* FLUORESCENT FIXTURES

Millinery or motor cars, foods or furniture—all merchandise moves faster, with less sales effort, when correctly lighted. Because the Leader line of fluorescent fixtures for commercial use is complete and provides the right fixture for any installation, Leader fixtures are easier to sell, too.

NHC—480 Leader "New Horizon" with Slimline tubes. Creates new opportunities for modern lighting, efficiently, with low maintenance costs, versatility of surface brightness, and higher illumination values.

TL-240 Leader "Trofferlite." With many new and exclusive features, Leader's new Trofferlite fixtures are ideal for remodeling or for new construction. For mounting as single units or in continuous rows.

Better Light means Better Business



SM-240 Leader "Schoolmaster." A newly styled fluorescent fixture for schoolroom use. Optional feature is a built-in germicidal lamp. The Schoolmaster is also ideal for commercial use.

VL-440 Leader "Officer" America's most beautiful fluorescent fixture. Wafer thin. White molded plastic destaticized louvers assure maximum soft light diffusion. May be mounted singly or in continuous rows.

Leader Adjustable "Direclite." May be mounted above a display case in a continuous run of "Officer" units . . . or with a single unit . . . to spotlight merchandise for added sales appeal.

See the Leader Lighting Exhibit at Booth 124

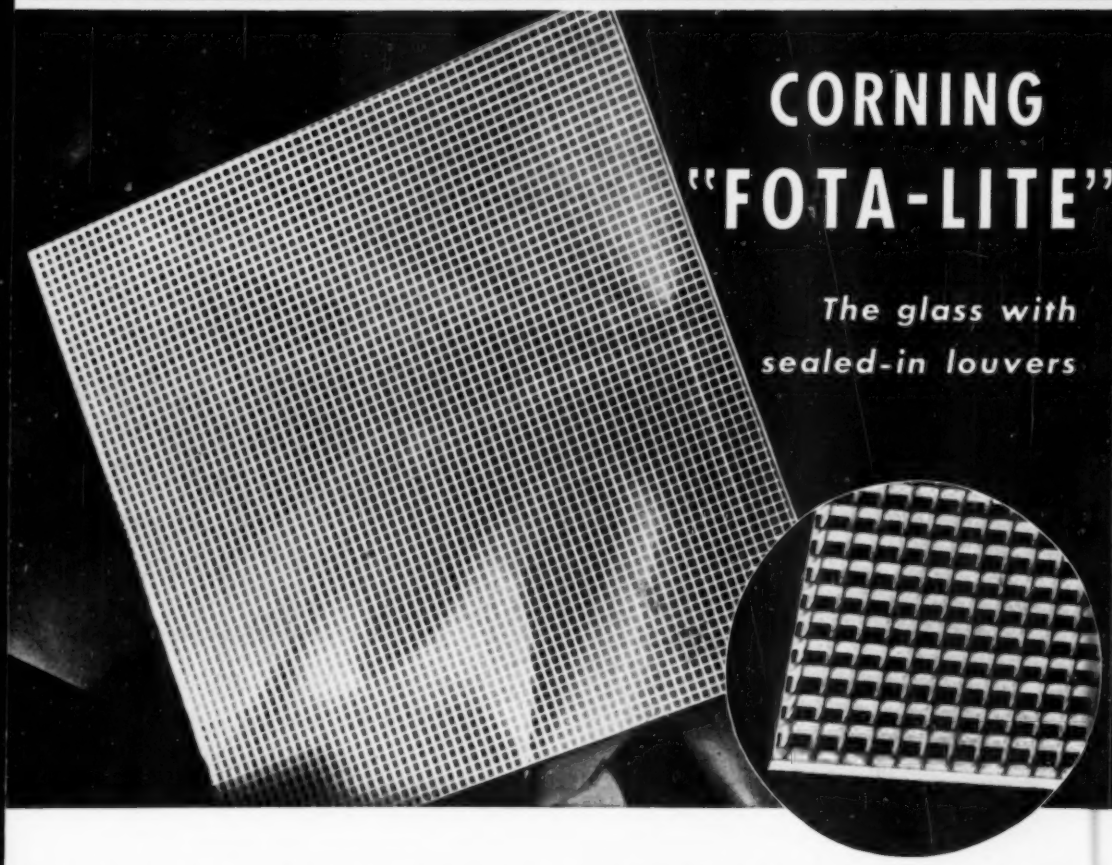
Only better electrical wholesalers and contractors distribute and install Leader fixtures.

LEADER ELECTRIC COMPANY

3500 N. KEDZIE • CHICAGO 18, ILLINOIS

WEST COAST FACTORY: 2040 LIVINGSTON STREET • OAKLAND 6, CALIF.

Something *Really* NEW in lightingware



CORNING "FOTA-LITE"

The glass with sealed-in louvers

Now you can get "egg crate" fluorescent lighting effect *without the egg crate!* Corning "Fota-Lite" is a new glass in which vertical louvers are photographically transferred to the full thickness of the glass.

EASY TO CLEAN. "Fota-Lite" presents a smooth surface which you can wipe clean quickly—something that is impossible with ordinary exposed louvers. Since you can completely enclose the fixture, both tubes and reflectors also remain clean. Thus, you never lose original efficiency through the accumulation of grime and dust.

HIGH EFFICIENCY. Brightness at high angles is low. Yet, the transparent area is comparable to the finest crystal. Light directed vertically is almost unrestricted but a slight surface diffusion obscures tubes and reflectors. The 45° cut off is obtained within the thickness of the glass (1/8") instead of bulky and costly louvering materials.

NO COLOR CHANGE. The opalescent louvers are nonselective in color transmission and as they are sealed within the glass surface, discoloration is impossible. This is important in maintaining original color values.

CORNING means research in GLASS

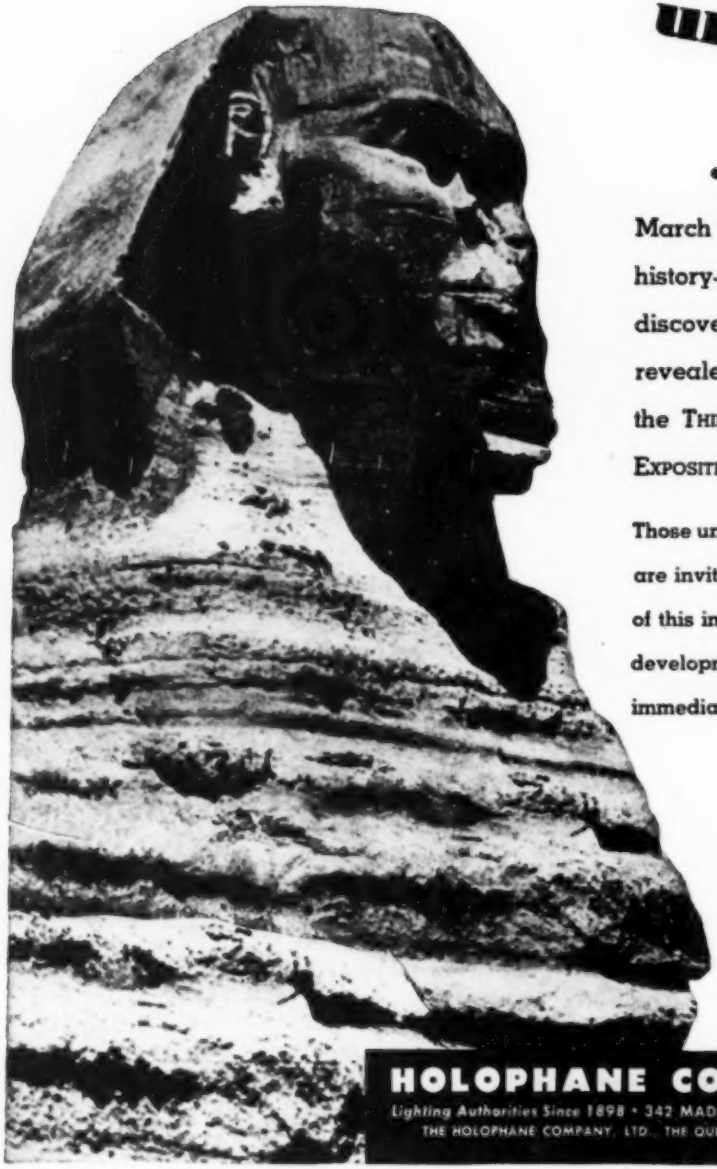
PYREX T.M. REG. U.S. PAT. OFF.

SEE this sensational new development at the Corning Exhibit, International Lighting Exposition, Booth No. 13, Hotel Stevens, Chicago, March 29 to April 1, or write for further information.

LIGHTINGWARE

CORNING GLASS WORKS, CORNING, NEW YORK

it can't be told until



March 29th . . . when the history-making new lighting discovery by Holophane will be revealed . . . in Booths 11 & 12 at the THIRD INTERNATIONAL LIGHTING EXPOSITION, STEVENS HOTEL CHICAGO

Those unable to attend the exposition are invited to write for full details of this important lighting development which will be released immediately on March 29th.

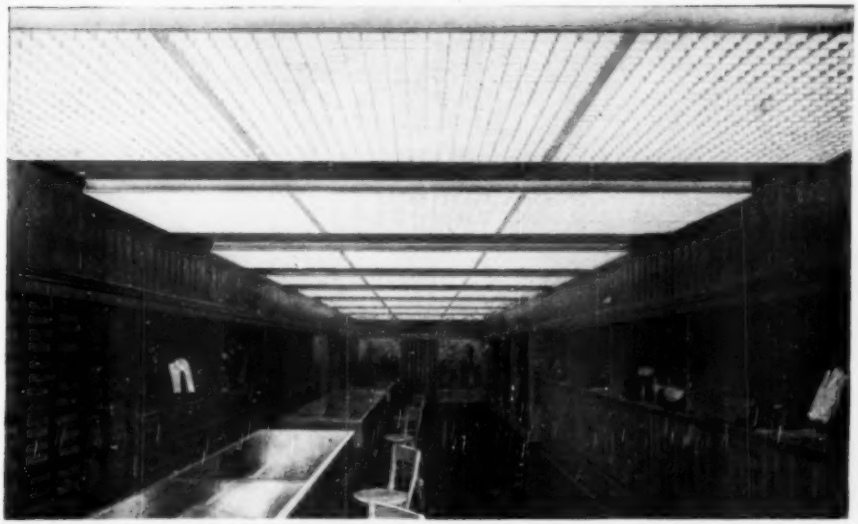
Holophane

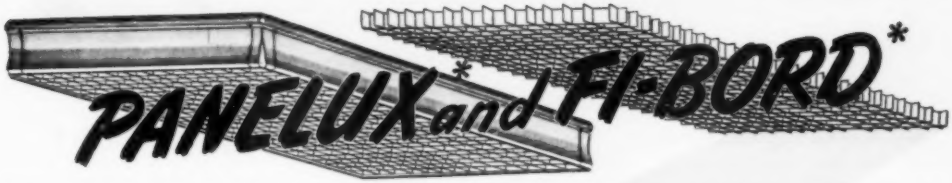
HOLOPHANE COMPANY, INC.

Lighting Authorities Since 1898 • 342 MADISON AVENUE, NEW YORK 17, N.Y.

THE HOLOPHANE COMPANY, LTD., THE QUEENSWAY, TORONTO 14, ONTARIO

LPI PANELUX and Fi-bord "Bring the Rainbow Indoors"





1. COMPLETE FIXTURE . . . Each Panelux is a complete unit, with chassis, louvers and hangers. Installation is a single operation, eliminating any need for individual fixtures and louvers installed separately.

2. FOUR SIZES...The four Panelux sizes can be joined together end-to-end or side-by-side to achieve any desired pattern.

3. MODERN DESIGN...High reflection, brightness control and a shielding angle of 38° provide comfortable, glareless illumination. Proper light distribution virtually eliminates shadows.

1. FIVE COLORS...Fi-bord (fiber-board) Louvers are available in white and in pastel shades of blue, green, pink and yellow. Colors can be used individually or in attractive combinations.

2. EASY INSTALLATION...Fi-bord is light in weight and easy to handle. Folded sections open quickly for installation in less than two minutes per unit. A light metal angle keeps louvers rigid.

3. NO MAINTENANCE...You *don't clean* Fi-bord Louvers. You *replace* them—at less cost and in less time than are required for cleaning any other louvers. Replacement requires only one man.

Here's the fluorescent luminaire with Fi-bord Louvers in five colors that bring the rainbow indoors. Wholesalers, contractors, architects and engineers all agree that this combination produces the world's finest louverall ceiling.

Remember, only LPI has Panelux, and only Panelux has Fi-bord Louvers. Write LPI today for Panelux Bulletin No. 420, or contact the LPI Representative nearest you.

All LPI fixtures are union made (I.B.E.W.—A.F. of L.)
They're sold nationally through leading electrical wholesalers

Lighting PRODUCTS, INC.
HIGHLAND PARK, ILLINOIS

*Trade Marks—Patents Pending

Visit us at the Lighting Exposition — Booths 70 and 71.

Build more "SELL" into your product with G-E Components

This simple action...

makes fast friends with fluorescent buyers

G-E Turret* lampholders make relamping a fast, easy, one-hand job.
Here's how: Just push in spring-backed contact plate with one end of lamp—and turn lamp slightly to seat pins.
Next swing free end of lamp up, and "pop"—lamp slides firmly into place.
Snug fit and uniform spring tension hold lamp securely in place—automatically hold lamp in firm contact.

But what does this easy-maintenance story mean to you, the fixture manufacturer? Just this: because Turret lampholders offer these features, and are rapidly gaining wide acceptance as the most modern lampholder, they are an added argument in your sales story.

From your production standpoint, the Turret story is excellent, too. A choice of three sizes simplifies fixture design and permits a wide variation of lamp arrangements. They mount easily on any flat surface—terminal holes are marked for accurate identification—starter sockets are built in. And *they are easy to wire.*

Why not check the many features Turret lampholders offer? Just contact the G-E accessory equipment representative in your area, or write to Section Q46-387, Construction Materials Department, General Electric Company, Bridgeport 2, Connecticut.

FLICKERING AND BLINKING fluorescent lamps are a thing of the past when fixtures are equipped with G-E Watch Dog* starters. Keep your customers happy long after installation by making Watch Dogs standard equipment on the fluorescent fixtures you build. They stop lamps cold when they begin to flicker and blink—prolong starter and ballast life. Watch Dogs can be reset by merely pushing the reset button.

A COMPLETE COMPONENT LINE is available to fixture manufacturers. Behind every product in this line are rigid engineering and quality control, to insure uniform, high performance. And all are backed by General Electric—the best-known name in the electrical field—another helpful point in your *quality* sales story.

CIRCLINE LAMPHOLDERS—To give you complete design flexibility on Circline fixtures, General Electric offers two types of lampholders. The channel type includes two-point mounting, complete with starter switch and leads. These units are furnished with threaded bushings for easy assembly. The individual-type lampholders offer three-point mounting—one support with leads for electrical connections, and two tension supports.

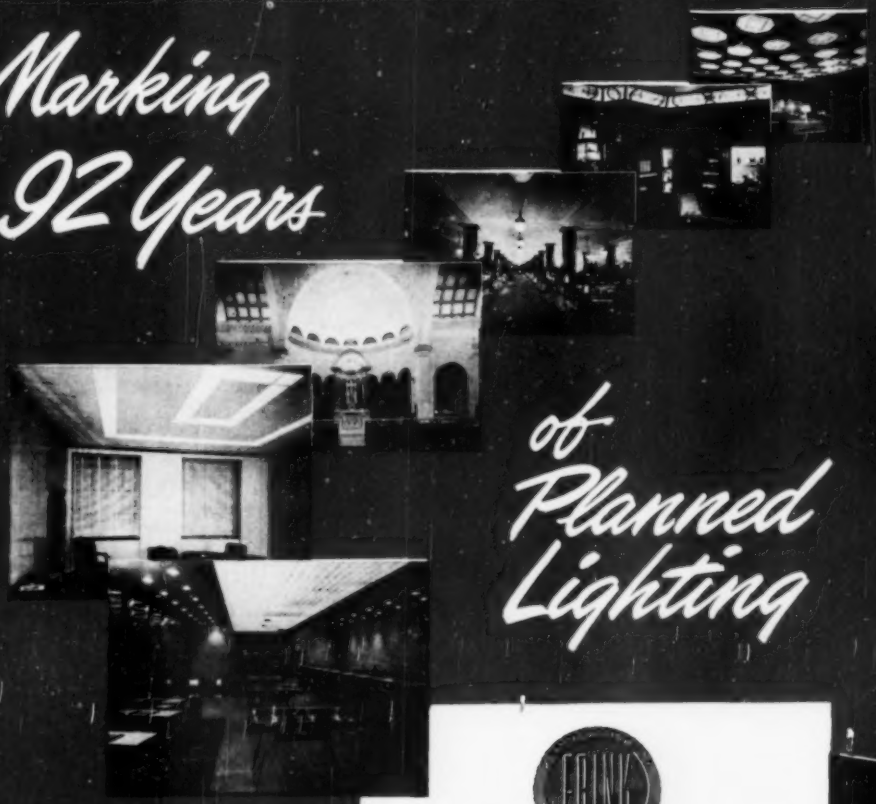
For information, contact your G-E accessory equipment representative, or write to Section Q46-387, Construction Materials Department, General Electric Company, Bridgeport 2, Conn.

*Trade-mark Reg. U. S. Pat. Off.

GENERAL ELECTRIC

Turret Lampholders

Marking 92 Years of Planned Lighting



by FRINK

FRINK

You are cordially invited to see the outstanding collection of 1949 FLUORESCENT FIXTURES, featuring exclusive new standard and custom designs for schools, stores, banks, offices and public buildings, exhibited by

THE FRINK CORPORATION

Spaces 38 and 39

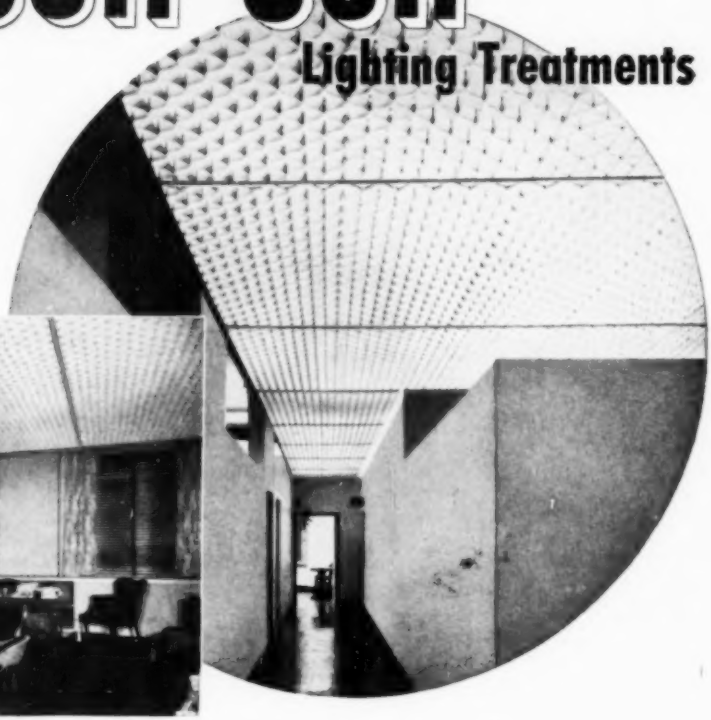
3rd International Lighting Exposition

Hotel Stevens, Chicago, Illinois

New BEAUTY *with*

FEDERAL Cell-Ceil*

Lighting Treatments



Foyers, display rooms and offices take on new life and glowing beauty with the installation of Federal Cell-Ceil, the most modern lighting treatment.

This beautiful overall ceiling louvering is easy to install. The light-weight sturdy hanging mechanism developed for Cell-Ceil not only speeds up application but provides such easy access for relamping and cleaning that continued satisfaction to the client is assured.

Wherever you specify Federal Cell-Ceil you assure those who work and live under this louvered ceiling a soft diffused light. With all direct glare reduced and bad effect of sharp shadows eliminated, uniform lighting is provided that allows better easier-on-the-eye seeing.

The Federal engineering staff will gladly advise on any installation problem. Our technical bulletin on installation techniques is also available, address Dept. CC-9.

*Trade Mark "Cell-Ceil" applied for.

FEDERAL ENTERPRISES, INC.

Formerly: FEDERAL ELECTRIC COMPANY, INC.

8700 S. STATE STREET • CHICAGO 19, ILLINOIS

MOTORING TIME IS JUST AROUND THE CORNER

Soon hundreds of thousands of cars that have been used little or not at all during the winter months will take to the road. When they do, brightly lighted Service Stations loom through the darkness as friendly guides along strange highways. Pemco's complete line of Service Station Lighting Equipment will harmonize with the architecture of any type Station. From one to five PAR-38 150 watt Flood-Spot Lamps or 500-300 watt Hard Glass Reflector Flood Lamps may be mounted on a single Island Luminaire or Pole. Larger type Floodlighting Luminaires are included in the Pemco Line as are Poles of all types, Pump Extension Adapters and Fluorescent Lighting Units. Pemco Service Station Lighting Equipment is available in a variety of colors to match or blend with the color scheme of practically every Station.

PHILADELPHIA ELECTRICAL & MFG. CO.

1200-36 NORTH 31st STREET • PHILADELPHIA 21, PENNA.

Catalog No. 89 will give you full details and specifications covering Pemco's complete line of Service Station Lighting Equipment as well as engineering helps. To obtain your copy attach coupon to your business letterhead and mail today.

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1200-36 N. 31st St., Phila. 21, Pa.

Please send copy of Pemco Service Station Catalog No. 89 to

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Position .....

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MAR 29 TO APR 1 '49 STEVENS HOTEL

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plan now to attend

interesting events every day

merit award competition

To best solve today's and tomorrow's Planned Lighting problems you need, NEW Light on Planned Lighting. **Attend the THIRD INTERNATIONAL LIGHTING EXPOSITION and CONFERENCE.** There will be outstanding exhibits by leading lighting equipment manufacturers . . . new developments and designs . . . more Merit Award Winning Case Studies . . . and still better conferences than those that enthused and inspired over 15,000 visitors at the First and Second Lighting Expositions.

Come to see the latest advances in Planned Lighting for all lines of Business, Industry, Schools, Theaters, Service Stations, Airports, Play Areas, etc.—to hear lighting authorities reveal the latest developments in Illumination Technique, Lighting Trends and Progress, Selling Plans, Installation and Maintenance Methods; Benefit by Round-table Comment; meet men who have the same Planned Lighting problems as you—and learn how they are solving them!

NO WAITING IN LINE if you mail in this COUPON

THE THIRD INTERNATIONAL LIGHTING EXPOSITION is sponsored as a public service by the Industrial and Commercial Lighting Equipment Section of the NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

APPLICATION FOR FREE ADVANCE REGISTRATION

TO THE **THIRD INTERNATIONAL LIGHTING EXPOSITION MANAGEMENT** • 111 WEST JACKSON BLVD., CHICAGO, ILL.

Without obligation, I wish to apply for free Advance Registration at the THIRD INTERNATIONAL LIGHTING EXPOSITION and CONFERENCE.

My badge of admission to Exhibit Hall is to be ready for me when I call for it at the Registration desk and there will be no waiting.

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MY POSITION IS .....

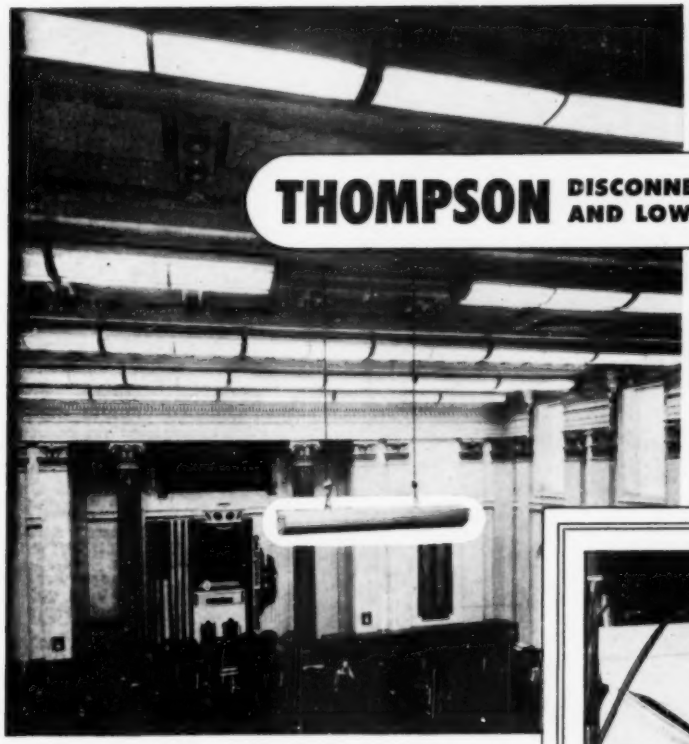
B-2793-B

This advertisement sponsored by Westinghouse Lighting Division. Visit our booths 80 to 85, inclusive.

Exhibiting at the International Lighting Show, Chicago, March 1949, Booths 14 and 15.

THOMPSON DISCONNECTING AND LOWERING HANGERS

make high bay FLUORESCENT LIGHTING *feasible*



Fixture being lowered

The problem of cleaning and relamping a high bay fluorescent lighting system approximately 33 feet above floor level and containing 382—40 watt 3500° white tubes can only be solved economically with Thompson Disconnecting and Lowering Hangers. That's why they were specified as an integral part of the lighting system in the State Assembly Chamber at Sacramento, Calif.

Each fixture is lowered separately to desk top level—electrically "dead." A simple test block arrangement is provided to facilitate final inspection after cleaning and relamping. The 250-pound units are easily winched back to operating position and are automatically re-connected.

MAKES AIR CONDITIONING PRACTICABLE

The former incandescent lighting system requiring a total connected load of 52,000 watts caused such a temperature rise that when added to normal summer temperature, it made the air conditioning system practically

Fixture being Relamped and Tested

ineffective. The use of fluorescent 40-watt 3500° white tubes provided 40 ft. candles at desk height and the low temperature rise solved the air conditioning problem.

The easy access to lighting fixtures afforded by Thompson Hangers permits frequent cleaning — scheduled relamping — and assures constant foot candles on the desk surfaces to specification.

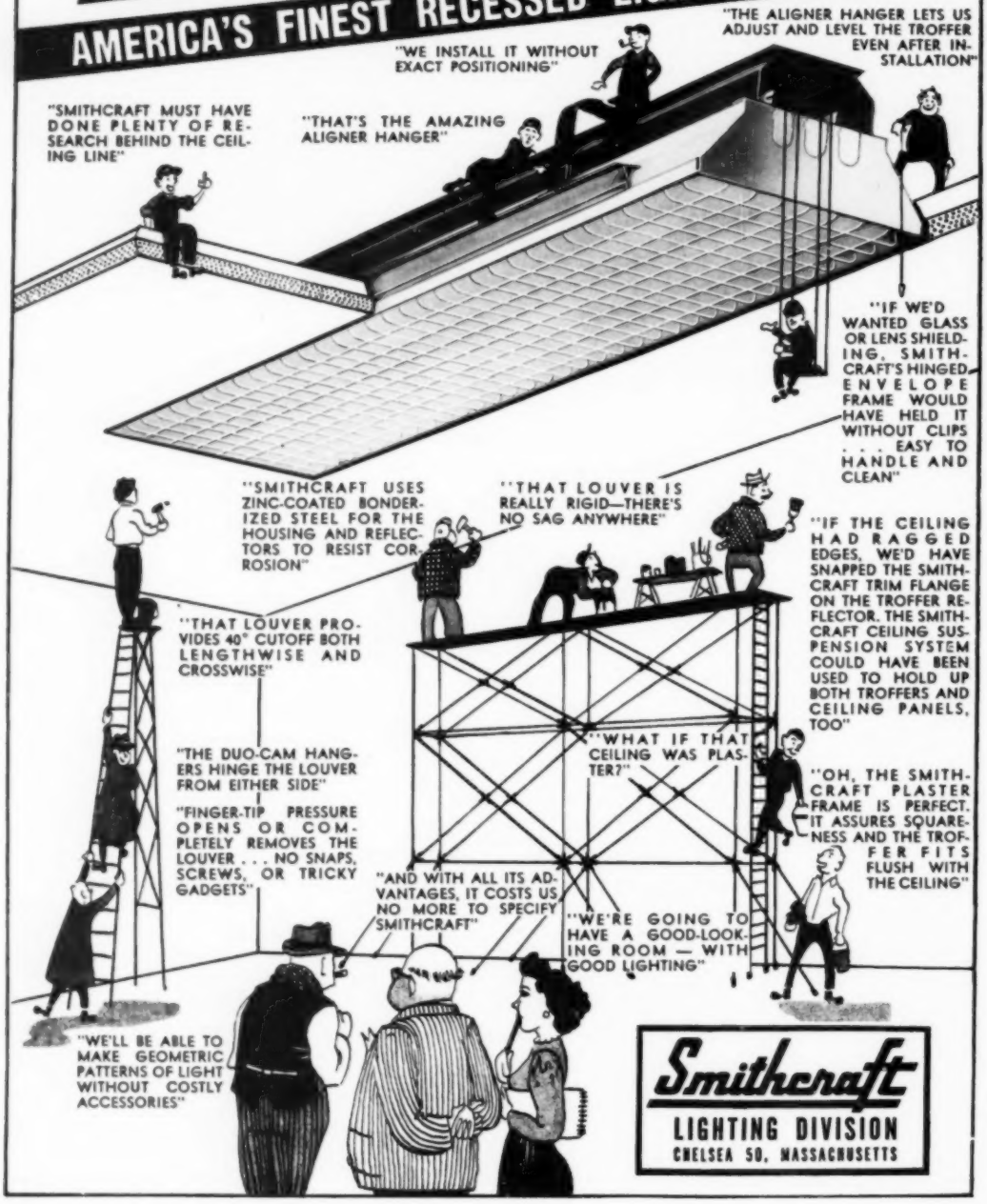
THOMPSON
DISCONNECTING & LOWERING
HANGERS

We invite you
to use THOMPSON Engineering Service

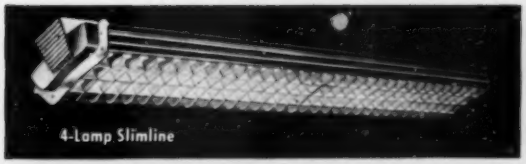
THE THOMPSON ELECTRIC CO.
1111 POWER AVENUE • CLEVELAND 14, OHIO

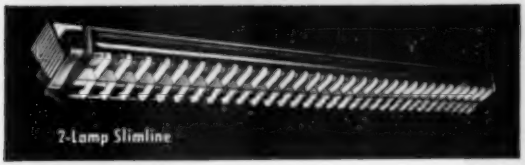
Smithcraft Troffers

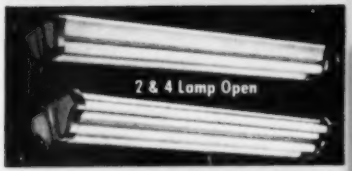
AMERICA'S FINEST RECESSED LIGHTING FIXTURES

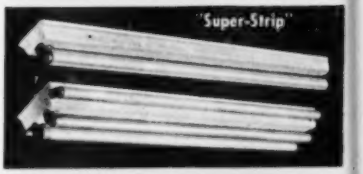

"THE ALIGNER HANGER LETS US ADJUST AND LEVEL THE TROFFER EVEN AFTER INSTALLATION"
"WE INSTALL IT WITHOUT EXACT POSITIONING"
"SMITHCRAFT MUST HAVE DONE PLENTY OF RESEARCH BEHIND THE CEILING LINE"
"THAT'S THE AMAZING ALIGNER HANGER"
"IF WE'D WANTED GLASS OR LENS SHIELDING, SMITHCRAFT'S HINGED ENVELOPE FRAME WOULD HAVE HELD IT WITHOUT CLIPS . . . EASY TO HANDLE AND CLEAN"
"SMITHCRAFT USES ZINC-COATED BONDERIZED STEEL FOR THE HOUSING AND REFLECTORS TO RESIST CORROSION"
"THAT LOUVER IS REALLY RIGID—THERE'S NO SAG ANYWHERE"
"IF THE CEILING HAD RAGGED EDGES, WE'D HAVE SNAPPED THE SMITHCRAFT TRIM FLANGE ON THE TROFFER REFLECTOR. THE SMITHCRAFT CEILING SUSPENSION SYSTEM COULD HAVE BEEN USED TO HOLD UP BOTH TROFFERS AND CEILING PANELS, TOO"
"THAT LOUVER PROVIDES 40° CUTOFF BOTH LENGTHWISE AND CROSSWISE"
"THE DUO-CAM HANGERS HINGE THE LOUVER FROM EITHER SIDE"
"FINGER-TIP PRESSURE OPENS OR COMPLETELY REMOVES THE LOUVER . . . NO SNAPS, SCREWS, OR TRICKY GADGETS"
"WHAT IF THAT CEILING WAS PLASTER?"
"OH, THE SMITHCRAFT PLASTER FRAME IS PERFECT. IT ASSURES SQUARENESS AND THE TROFFER FITS FLUSH WITH THE CEILING"
"AND WITH ALL ITS ADVANTAGES, IT COSTS US NO MORE TO SPECIFY SMITHCRAFT"
"WE'RE GOING TO HAVE A GOOD-LOOKING ROOM — WITH GOOD LIGHTING"
"WE'LL BE ABLE TO MAKE GEOMETRIC PATTERNS OF LIGHT WITHOUT COSTLY ACCESSORIES"

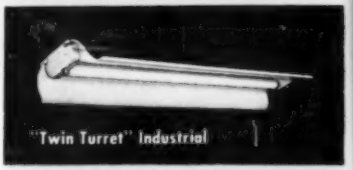
Smithcraft
LIGHTING DIVISION
CHELSEA 50, MASSACHUSETTS











NOW OVER 150 MODELS

in the MITCHELL COMPLETE LIGHTING LINE!

Build your lighting business *profitably* around the *one complete line* that covers your entire market. The MITCHELL Line—now well over the 150-model mark—is the most complete and diversified in the industry. This progressive development of "in demand" preferred quality merchandise, priced for profitable volume sales, gives you a powerful selling "edge." Here are your MITCHELL merchandising advantages:

1. **Everything you need from one source**
2. **An ever-growing line that helps you grow**
3. **Strong acceptance in the lighting field**
4. **High saleability — competitive price — Guaranteed standards of quality**

It's good business to concentrate your selling program around MITCHELL—the *complete lighting line* that builds solid business and bigger sales for you.

YOU'LL SELL THEM ALL

WRITE FOR FULL CATALOG AND DETAILS

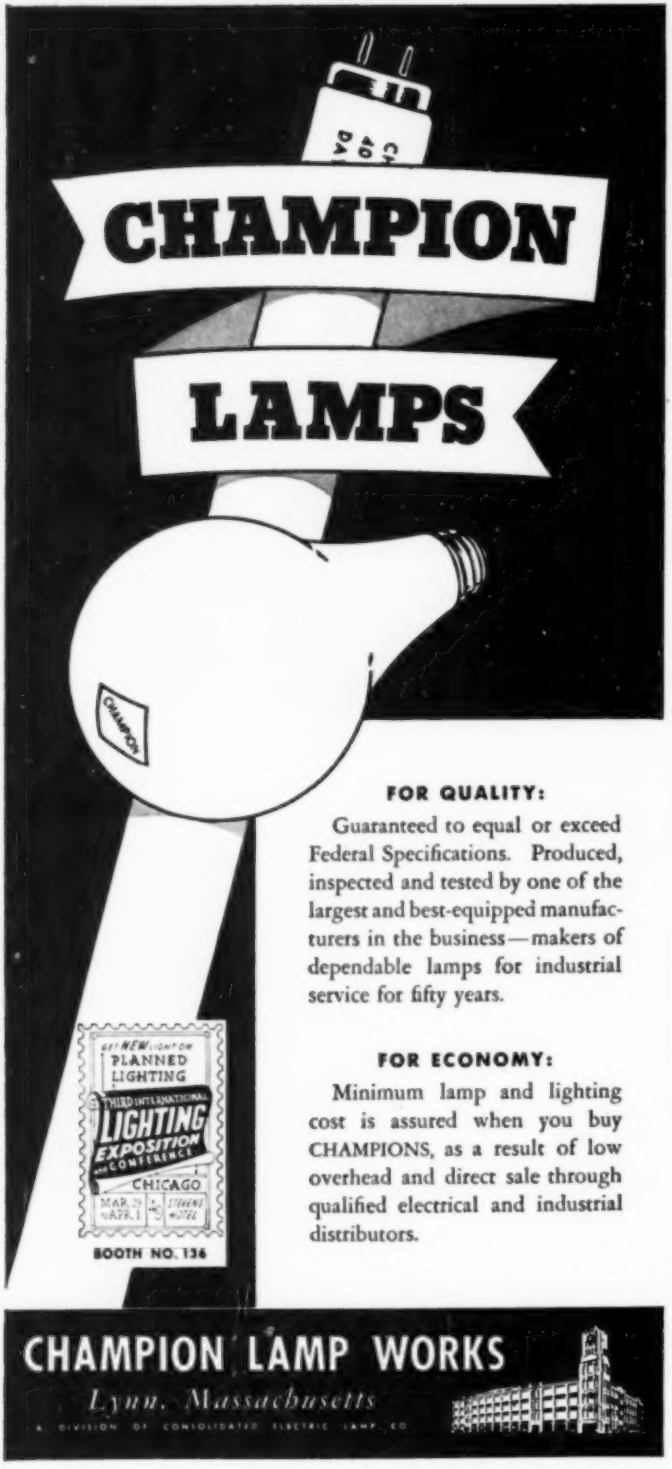
MITCHELL

Mitchell Manufacturing Company

2525 CLYBOURN AVENUE, CHICAGO 14, ILLINOIS

In Canada: Mitchell Manufacturing Company, Ltd., Toronto, Canada

First Choice in Lighting • The Pioneer Line that Keeps Growing


CHAMPION
LAMPS
CHAMPION
FOR QUALITY:
Guaranteed to equal or exceed Federal Specifications. Produced, inspected and tested by one of the largest and best-equipped manufacturers in the business—makers of dependable lamps for industrial service for fifty years.
FOR ECONOMY:
Minimum lamp and lighting cost is assured when you buy CHAMPIONS, as a result of low overhead and direct sale through qualified electrical and industrial distributors.
GET NEW LIGHT ON PLANNED LIGHTING
THIRD INTERNATIONAL LIGHTING EXPOSITION AND CONFERENCE
CHICAGO
BOOTH NO. 136
CHAMPION LAMP WORKS
Lynn, Massachusetts
A DIVISION OF CONSOLIDATED ELECTRIC LAMP CO.

(*Continued from page* 189)

has recently been received at Headquarters. When the Road Research Board's program was widened during past months to include safety problems, the Ministry of Transport in Great Britain asked that the question of headlamp "dazzle" receive special attention. A survey was therefore carried out. A report of the survey has now been issued to the press with details of proposals for abating the nuisance because it was felt that the information should be available as quickly as possible. "Road Research Technical Paper No. 14—Interim Measures for the Prevention of Dazzle on Roads," published for the D. S. I. R. by H. M. Stationery Office, price 6d (20 cents, U. S. A.) by post 7d, gives a full account of the survey and the statistics on which the recommendations were based.

The main conclusion of the survey was that "dazzle" was caused more frequently by an incorrect alignment of lamps than by failure on the part of motorists to use dipping mechanisms. It was also found that low-mounted passlamps were more likely to dazzle than dipped headlights.

A regulation made by the Minister of Transport as a result of the survey provided that on and after January 1, 1949, a lamp mounted with its center less than two feet from the ground would not be held to comply with the Road Vehicles Lighting Regulations, 1936, Great Britain, unless the lamp were used only in fog or when snow was falling. It was proposed later to fix an upper limit of 3 feet, 6 inches and a lower limit of 2 feet, 6 inches for headlamps and passlamps on all cars registered for the first time on or after January 1, 1951.

The Board reported that a satisfactory solution of the problem of dazzle will not be reached until improved and standardized forms of light-beam are available. Research is continuing with this object, but at the present time, it is reported that it is the driver himself who can do most to reduce dazzle by seeing that his own lamps comply with the rules and are properly adjusted. Methods of testing the alignment of headlamps are given in the Technical Paper.

The Incandescent Light, a new book on Edison's experimental work on electric light has just been released by the Thomas Alva Edison foundation. Timed for release on the 102nd anniversary of Edison's birth on February 11, the book is the first of a projected series of studies, each to deal with one of Edison's major inventions.

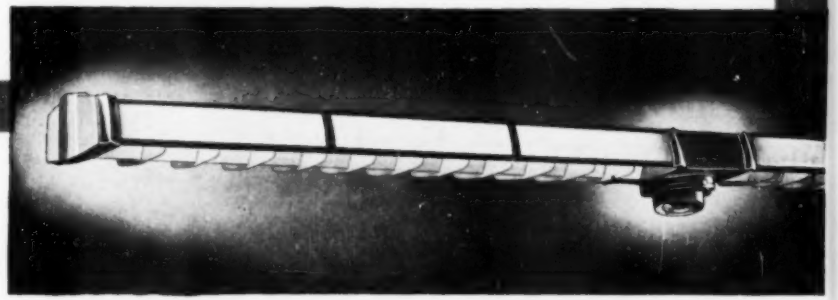
(*Continued on page* 23A)

These are the Wakefield "Spots"

Grenadier

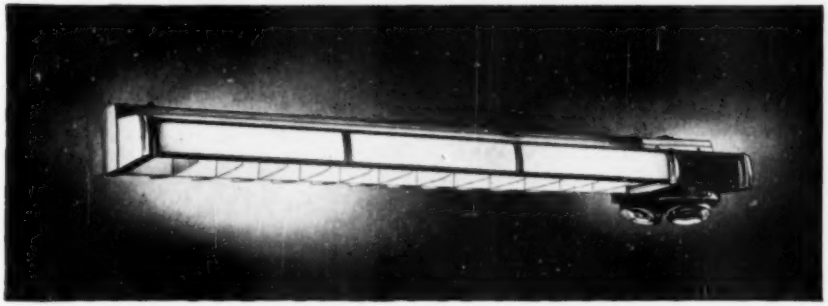
for double-duty store lighting...

In any installation where "spot" lighting and general lighting are desirable, you can recommend the Wakefield Grenadier "Spots" to do the double job with complete confidence. To all the proved advantages of the regular Grenadier has been added the plus advantage of an excellently designed spotlight assembly. Wakefield Grenadiers are finely engineered louvered units with translucent white plastic side panels. All metal parts are beautifully finished in soft metallic satin. For complete details on Grenadiers and the entire Wakefield line, you should have our fully illustrated, factually written, 36-page catalog. Write for your copy today.



THE GRENADIER II "SPOT"

Takes two 40W fluorescent lamps in each 4' section. Each 4' section has a single adjustable "spot" taking a 150W Sealed-Beam lamp.



THE GRENADIER IV "SPOT"

Takes four 40 W fluorescent lamps in each 4' section. Each 4' section has two adjustable "spots", each taking a 150 W Sealed-Beam lamp.

Wakefield Over-ALL Lighting

FOR OFFICE • DRAFTING ROOM • STORE AND SCHOOL

The New Handy

STEBERLITE

Flood and Spotlight Holder

For Parking Lots, Gas Stations, Recreation Areas, and House Gardens, the Steberlite lamp holder—for 150 Watt Par-38 and R-40 lamps is a flexible inexpensive method of spot and flood-lighting. Steberlites are easily installed anywhere and can be used singly, in pairs, or clusters of 3, 4 and 5.

They are smartly styled and sturdily constructed with all wiring concealed for long life and complete safety. Steberlites make it possible to have good, effective lighting at a surprisingly low cost. Let us mail you a copy of new Bulletin 120. It contains many helpful lighting hints.

Write for new Bulletin 120

STEBER

LIGHTING UNITS

STEBER MANUFACTURING CO. Dept. 74

2700 ROOSEVELT ROAD, BROADVIEW (MAYWOOD P. O.), ILLINOIS

(*Continued from page* 21A)

An interesting history and description of experimental work with incandescent lamps by other scientists is included in the book as well as detailed accounts of Edison's experiments, based on his own notebooks.

Publication in a single pamphlet of a series of papers on the subject "What Good are Standards?" is announced by the American Standards Association. The papers which were presented at the 1948 annual meeting of the Association, include discussions of such important problems as the legality of standardization, the standardization work of the Munitions Board and the functions of standardization in such company operations as purchasing, manufacturing and marketing. The importance of standardization to wholesalers and retailers and to the ultimate consumer as well as to manufacturers is taken up by authorities in each field.

Copies can be obtained from the American Standards Association at $1.00 for nonmembers.

Current Articles on Lighting

The following list presents titles and source of publications of current articles on lighting and allied subjects which have appeared in recent issues of nationally-known magazines having a wide circulation.

Darkness Is Danger, by J. C. Furnas, *Colliers*, February 12, 1949, p. 11.

Intangibles Turn Into a Real 40% Increase, *Electrified Industry*, January, 1949, p. 28.

A Theater Designed with Light Meters, *Architectural Record*, November, 1948, p. 130.

Lighting Movie Theater Interiors, by H. L. Logan, *Architectural Record*, November, 1948, p. 145.

Lighting and Decoration in a Windowless Factory, by E. J. Ward, *Light and Lighting*, December, 1948, p. 257.

New Lighting Installations, *Light and Lighting*, December, 1948, p. 266.

Landing Lights for Helicopters, *Light and Lighting*, December, 1948, p. 269.

Minimum Glare, by Val J. Roper, *Traffic Engineering*, January, 1949, p. 151.

Colour and Lighting in Factories and on Machines, *Light and Lighting*, January, 1949, p. 15.

Louverall for High Level Lighting, by Furna E. Lott, *Electrical South*, February, 1949, p. 41.

Minimize Lamp Flicker with Low-Drop Circuits, by Jefferson D. Brooks, *Electrical South*, February, 1949, p. 44.

(*Continued on page* 24A)

(*Continued from page* 23A)

Luminosity—The Key to Store Lighting, *Lighting and Lamps*, January, 1949, p. 24.

Exclusive Lighting Showroom Attracts Shoppers in Buffalo, N. Y., *Lighting and Lamps*, January, 1949, p. 27.

Decorative Lighting in Hotels, *Lighting and Lamps*, January, 1949, p. 30.

Lighting Brings New Spirit to Ready-to-Wear Departments, *Lighting and Lamps*, January 1949, p. 32.

Lighting Fixtures from Acrylic Sheet, *Lighting and Lamps*, January, 1949, p. 36.

Cold Cathode Fluorescent Lighting, by John W. Lewis, *School Board Journal*, January, 1949, p. 29.

Lighting Plus Decoration in Ft. Worth Installation, *Signs of the Times*, February, 1949, p. 69.

New High School Uses Four Light Sources, by Howard M. Sharp, *Signs of the Times*, February, 1949, p. 70.

Good Lighting for Good Drafting, *Electrified Industry*, February, 1949, p. 39.

Design on Contact Lights for Aerodrome Runways, by H. J. Turner, *Transactions of the Illuminating Engineering Society* (London), No. 1, 1949, p. 1.

Research for the Motion Picture Industry, *Standardization*, February, 1949, p. 36.

Quality in Lighting, *Electrical Review*, January 21st, 1949, p. 126.

Headlighting Without Glare, by Val J. Roper, 1948 *Proceedings*, Institute of Traffic Engineers, p. 17.

Relighting a City, by Thomas J. Seburn, 1948 *Proceedings*, Institute of Traffic Engineers, p. 59.

Brighter High School Days in New Kensington, *Better Light — Better Sight News*, Vol. 16, No. 8, p. 2.

Can Your Children Really See?, *Better Light—Better Sight News*, Vol. 16, No. 8, p. 4.

Saving Time With Light, by R. H. Scott, *Better Light — Better Sight News*, Vol. 16, No. 8, p. 6.

From Poor Seeing to Easy Seeing in Maybrook School, *Better Light—Better Sight News*, Vol. 16, No. 8, p. 8.

More Light on the Subject, *Standardization*, January, 1949, p. 8.

Articles on Home Lighting

For Good Living Your House Needs Good Lighting, *House and Garden*, February, 1949, p. 86.

Pick the Right Lamp and Get Better Lighting, by Harry Richardson, *Better Homes and Gardens*, February, 1949, p. 224.

(*Continued on page* 26A)

HOLDENLINE'S "*Arrowhead*"

Works Here!

Cleveland's Public Square Building has joined the rapidly-growing group of office buildings, schools, stores, and hospitals which has found in the HOLDENline ARROWHEAD the answer to the basic architectural problem of commercial installations—comfortable, even illumination supplied by beautiful, yet inconspicuous fixtures designed to remove consciousness of the lighting source.

The remarkable ARROWHEAD coefficient of utilization—talk of the fluorescent industry—has gone to work to provide the Public Square Building with 50 footcandles of maintained illumination, secured with an irreducible minimum of luminaires.

A steady stream of lighting authorities has discovered in this new installation further evidence that the ARROWHEAD stands alone as a symbol of peerless achievement. The facts speak for themselves:

9' 6" centers on a 9' 8" ceiling... no dark areas between fixture rows... no "bright spots" above the fixture... no dark-to-bright contrast within the fixture... shielding comfort even at sustained transverse viewing

More light, better controlled, at less cost—the promise which the all-plastic-louvered, fully-guaranteed ARROWHEAD has fulfilled for the Public Square Building and many, many others it is prepared to deliver for *you* as well. Ask to see it today!

HOLDENLINE Co.

Pioneers In Fluorescent

2287 Scranton Rd. • Cleveland 13, Ohio

HOLDENLINE—T.M. REG. U. S. PAT. OFF. 1937

ACCEPT NO SUBSTITUTE FOR ACME ELECTRIC BALLAST PERFORMANCE

Compare the construction features and better performance of Acme Electric ballasts and you'll see why fluorescent lamps provide more light, last longer, prevent end blackening when an Acme Electric ballast controls the current. Write for Bulletin FL 167 which gives valuable information concerning the operation and selection of proper ballasts for your fixtures.

ACME ELECTRIC CORPORATION
293 Water Street **Cuba, N. Y.**

Acme Electric

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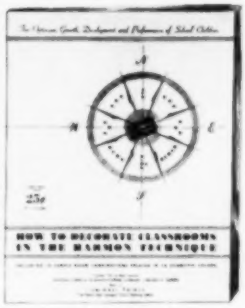

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(*Continued from page 24A*)

New Ideas for Home Modernization with Light, *Better Light—Better Sight News*, Vol. 16, No. 8, p. 10.

Farm Homes Need Better Lighting, *Better Light—Better Sight News*, Vol. 16, No. 8, p. 9.

Easy on the Eyes, excerpt from book of this title by Winifred Hathaway, *Better Light—Better Sight News*, Vol. 16. No. 8, p. 12.

The ABC's of Good Lighting, by Ethel Owen Adair, *The Progressive Farmer*, November, 1948, p. 90.

I.L.E. AWARDS

(*Continued from page 141*)

These awards have become among the most highly prized honors that can be accorded for excellence in the field of planned lighting and contestants have spared no efforts in making this year's case studies the most fully illustrated and completely documented of any similar competition. The opportunity of seeing the winning entries and meeting the men who prepared them should alone be worth the trip to the Lighting Exposition.

Advance Registrations

The largest attendance at any lighting exposition is anticipated. A number of I.E.S. Sections are making a concerted effort to have a large part of their membership attend. Those who have not yet made hotel reservations are urged to write Thomas Paris, Reservations Dep't., Stevens Hotel, or any other Chicago Hotel of their preference. Requests for advance registrations and free tickets should be addressed to the Third International Lighting Exposition, 111 West Jackson Blvd., Chicago 4, Illinois.

Complete Program Booklet Available

A 36-page booklet has been prepared, containing the complete program for the Third International Lighting Exposition and conference, with a brief biography of each speaker. This booklet also contains a full list of exhibitors and other information on what the show has in store for visitors. Requests for this booklet should also be sent to the Exposition Headquarters, address above.

List of Exhibitors, I.L.E.

(*Continued from page 142*)

Neo-Ray Products Co., Inc. 147–148
315 E. 22nd St.,
New York 10, N. Y.

Owens-Corning Fiberglas Corporation, 86–87
Toledo 1, Ohio.

(*Continued on page 28A*)

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(*Continued from page* 26A)

Paragon Electric Company, 16
1600 12th St.,
Two Rivers, Wis.

The Perfeclite Company, 26–27
1457 E. 40th St.,
Cleveland 14, Ohio.

The Phoenix Glass Company, 34
9th St. & Washington Ave.,
Monaca, Pa.

Pittsburgh Reflector Company, 91–92–93
403 Oliver Bldg.,
Pittsburgh 22, Pa.

Quadrangle Mfg. Company, 44
32 S. Peoria St.,
Chicago 7, Ill.

RLM Standards Institute, Inc., 140–141
326 W. Madison St.,
Chicago 6, Ill.

Revere Electric Mfg. Co., 102–103–
6009 Broadway, 104
Chicago 40, Ill.

Rohm & Haas Co., 137
222 W. Washington Sq.,
Philadelphia 5, Pa.

Ruby-Philite Corp., 72–73
342 W. 14th St.,
New York 14, N. Y.

Sandee Manufacturing Co., 17
5050 Foster Ave.,
Chicago 30, Ill.

Sangamo Electric Company, 42
Springfield, Ill.

L. J. Segil Co., Inc., 22–23
2500 W. North Ave.,
Chicago 47, Ill.

Silvray Lighting, Inc., 48
1270 Avenue of the Americas,
New York 20, N. Y.

Smitheraft Lighting Division, 1
A. L. Smith Iron Co.,
217 Everett Ave.
Chelsea 50, Mass.

Sola Electric Company, 96
4633 W. 16th St.,
Chicago 50, Ill.

Solar Electric Corporation, 31–32
121 Central Ave.,
Warren, Pa.

Solar Light Manufacturing Co., 65–66
1357 S. Jefferson St.,
Chicago 7, Ill.

The Spero Electric Corporation 6
18222 Lanken Ave.,
Cleveland 19, Ohio.

Sunbeam Lighting Company, 77–78
777 E. 14th Place,
Los Angeles 21, Calif.

The Superior Electric Co., 153–154
83 Laurel St.,
Bristol, Conn.

Sutton Publishing Co. Inc., 138
60 E. 42nd St.,
New York 17, N. Y.

Swivelier Company, Inc., 94–95
30 Irving Place
New York 3, N. Y.

Sylvania Electric Products,
Incorporated, 97–98–99
Ipswich, Mass.

(*Continued on page* 29A)

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(*Continued from page* 28A)

The Thompson Electric Co., 14–15
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Up-Right Scaffolds 152
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Verd-A-Ray Corporation 151
615 Front St.,
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The F. W. Wakefield Brass Co. 35–36–37
731 S. Water St.,
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Westinghouse Electric Corp.,
Lamp Division, 80–81–82
Bloomfield, N. J.
Lighting Division, 83–84–85
1216 W. 58th St.,
Cleveland 1, Ohio.

The Wheeler Insulated Wire Co. 40–41
Inc., Div. of The Sperry Corp.
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Manufacturer seeking qualified representative to handle line of commercial lighting fixtures in Ohio, Indiana, St. Louis and southern Illinois and Kentucky, and New York. Address Box 104, Publications Department, Illuminating Engineering Society, 51 Madison Avenue, New York 10, N. Y.

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CONDUIT FITTINGS • LIGHTING EQUIPMENT • OUTLET AND SWITCH BOXES
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Operates at Low Voltage and Temperatures

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Available for
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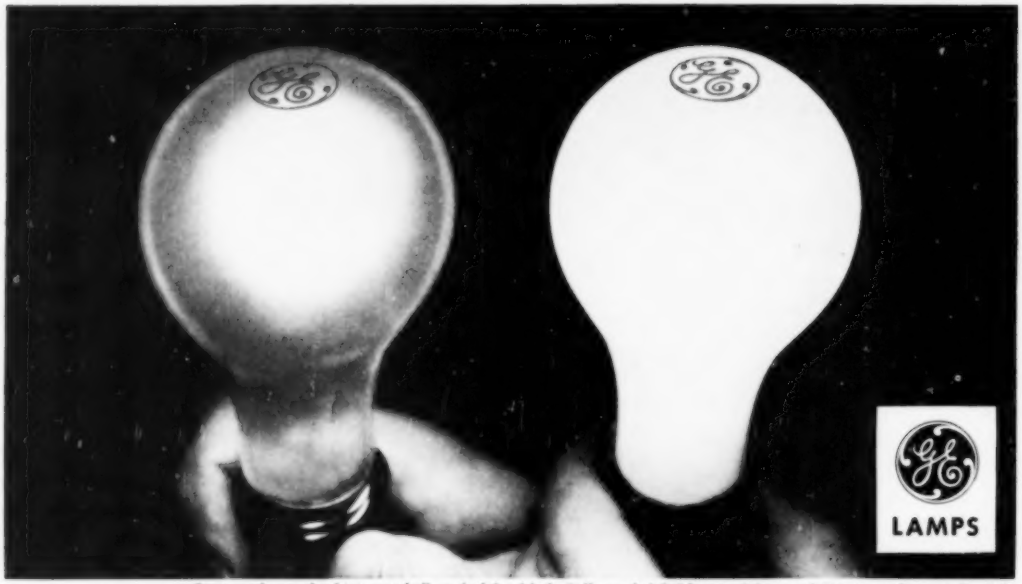
POWERSTAT VARIABLE TRANSFORMERS • VOLTBOX A-C POWER SUPPLY • STABILINE VOLTAGE REGULATORS

General Electric announces a new kind of lamp bulb!



Compare the standard 100-watt bulb on the left with the "all-over-bright" beauty of the new G-E 100-watt lamp on the right

General Electric lamp research has developed a new kind of lamp bulb that provides nearly perfect light diffusion. It's the greatest improvement in the quality of incandescent lighting since General Electric introduced the inside frosted lamp in 1925!

SOFTER LIGHT

The photograph above shows the difference between the new G-E Deluxe-White lamp and the standard inside frosted bulb. The new lamp spreads the light over the entire surface of the bulb. Its light is much softer and better diffused. Annoying reflections from glossy surfaces are greatly reduced.

GREATER BEAUTY

Both lighted and unlighted, this General Electric lamp has a clean-white beauty that lasts for the life of the bulb. Its softer shadows add new charm to house furnishings and interiors.

The Deluxe-White lamp is particularly recommended for portable lamps where bulbs are partially exposed or where there is no diffusing bowl. It will soon be available in limited quantity in the 100-watt size at only 20c, plus tax.

General Electric lamp research is always at work to develop new and better G-E lamps—and to make them *Stay Brighter Longer.*

LATEST STEP IN GENERAL ELECTRIC'S RESEARCH TO BRING YOU BETTER LIGHT

Four important steps in the development of the incandescent lamp are shown below. Left to right: Thomas Edison's first practical incandescent lamp of 1879, the outside frosted lamp of about 1910, the inside frosted lamp of 1925, and the new Deluxe-White lamp.

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The Fleur-O-Lier Index System supplies a concise, exact formula for expressing desired illuminating characteristics. The specifier can dictate desired light distribution, degrees of shielding, brightness and method of mounting. His specification is simple and precise. It's easy to write—and easy for the purchaser to follow.

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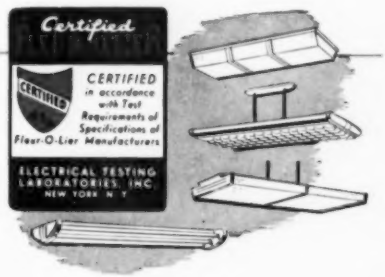
Fleur-O-Lier fixtures are carefully examined by Electrical Testing Laboratories, Inc., and assigned a rating under the Index System. All the buyer need do is select fixtures that meet the specifier's Index System number. Then with the photometric test data and the coefficients of utilization provided with all Fleur-O-Lier fixtures, he has complete information to make an intelligent purchase of fixtures that meet the specifications and perform efficiently.

**To get complete information on this easy way to specify and buy fixtures, write for free booklet, "The Fleur-O-Lier Index System".*

This label is attached to every FLEUR-O-LIER luminaire. It certifies that a similar fixture has been examined by Electrical Testing Laboratories, Inc., and found to conform to specifications. This label is your assurance of excellence in mechanical and electrical construction and in performance. It means that Certified Ballasts and Starters are used and that the requirements of the National Electrical Code have been met.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FLEUR·O·LIER

Manufacturers

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Fleur-O-Lier is not the name of an individual manufacturer, but of a group of fixtures made by leading manufacturers. Participation in the Fleur-O-Lier program is open to any manufacturer who complies with Fleur-O-Lier requirements.

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SLIMLINE FLUORESCENT

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In addition, it is designed for flexibility—it can be operated at loadings down to 400 amperes and at this loading has the brightness similar to standard 40 watt T-12s. It is, therefore, recommended for low mounting heights or where fixtures are unventilated and run hot.

ONLY MINOR ACCESSORY CHANGES

The new lamp is made in Daylight, White, 4500° White, Soft White, and Westinghouse Warm White. The 1½" bulb diameter can be used in existing fixtures. Only new ballasts are needed. These will be available from the Westinghouse Lighting Division, Cleveland, Ohio. Additional lampholders for the new bulb will be available from the Bryant Electric Company, Bridgeport.

For more information about the new Instant-Start Slimline, write Lamp Division, Westinghouse Electric Corporation, Bloomfield, N. J.

TECHNICAL DATA

Designation	F96-T-12 Slimline
Over-all Length (nominal)	96"
Bulb Diameter	T-12 (1½")
Base	Single Pin Slimline
Operating Amperes	.400 to .600
Operating Volts (approx.)	.400 amps. 200 .600 amps. 173
Lamp Watts (approx.)	.400 amps. 73 .600 amps. 96
Rated Avg. Life	2500 at 3 hours start 4000 at 6 hours start 6000 at 12 hours start

YOU CAN BE SURE ... IF IT'S Westinghouse
THE NAME YOU KNOW IN Lighting